AUGUST 1959

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 51 • NO. 8

A portrait of Mr. Water Works —saluting Harry E. Jordan at San Francisco *(see p. 38 P&R)*

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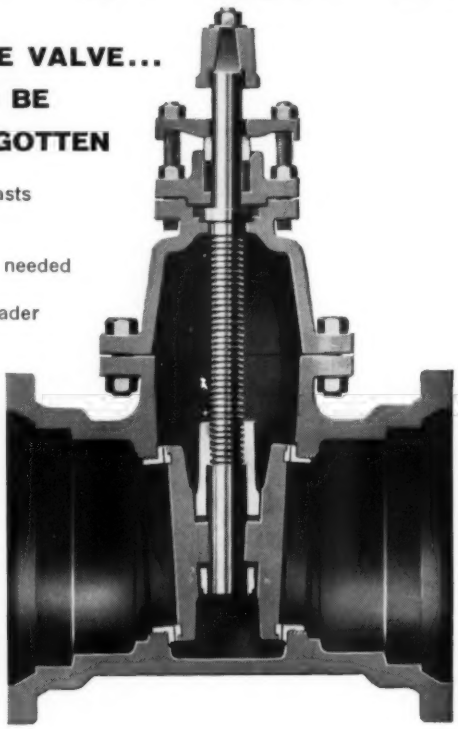

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Journal

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August 1959

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AWWA SECTIONS

Sep. 8–10—Rocky Mountain Section, at Jackson Lake Lodge, Moran, Wyo. Secretary, V. A. Vaseen, 833—23rd St., Denver 2, Colo.

Sep. 9–11—Canadian Section, Maritime Branch, at White Point Beach Lodge, Liverpool, N.S. Secretary, J. D. Kline, Gen. Mgr., Public Service Com., Halifax, N.S.

Sep. 9–11—Wisconsin Section, at Hotel Schroeder, Milwaukee. Secretary, Harry Breimeister, Chief Utilities Engr., City Engineer's Office, City Hall, Milwaukee.

Sep. 14–16—Kentucky-Tennessee Section, at Lafayette Hotel, Lexington, Ky. Secretary, J. Wiley Finney Jr., Howard K. Bell, Cons. Engrs., 553 S. Limestone St., Lexington, Ky.

Sep. 16–18—New York Section, at Saranac Inn, Upper Saranac Lake. Secretary, Kimball Blanchard, Neptune Meter Co., New York Branch Sales Office, 2222 Jackson Ave., Long Island City.

Sep. 16–18—North Central Section, at Pick-Nicollet Hotel, Minneapolis, Minn. Secretary, L. N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

Sep. 23–25—Michigan Section, at Bancroft Hotel, Saginaw. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, DeWitt Rd., Lansing.

Sep. 27–29—Missouri Section, at President Hotel, Kansas City. Secretary, Warren A. Kramer, Chief, Water Supply, Div. of Health, State Office Building, Jefferson City.

Oct. 7–9—Chesapeake Section at Sheraton-Belvedere Hotel, Baltimore, Md. Secretary, Carl J. Lauter, 6955—33rd St., N.W., Washington, D.C.

Oct. 8–9—Intermountain Section, Pocatello, Idaho. Secretary, W. C. Hague, Chief Engr., Metropolitan Water Dist., 703 Tribune Bldg., Salt Lake City, Utah.

Oct. 14–16—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 18–21—Alabama-Mississippi Section (with Southwest Section) at Roosevelt Hotel, New Orleans, La. Secretary, Ernest Bryan, Southern Sales Mgr., McWane Cast Iron Pipe Co., Box 2601, Birmingham, Ala.

Oct. 18–21—Southwest Section (with Alabama-Mississippi Section) at Roosevelt Hotel, New Orleans, La. Secretary, L. A. Jackson, Mgr.-Engr., Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 22–24—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

(Continued on page 8)

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Coming Meetings

(Continued from page 6)

Oct. 28–29—West Virginia Section, at Chancellor Hotel, Parkersburg. Secretary, Hugh W. Hetzer, Engr., Union Carbide Chemical Co., Box 8361, South Charleston.

Oct. 28–30—Ohio Section, at Biltmore Hotel, Dayton. Secretary, J. Howard Bass, Robt. F. McGivern & Assocs., 1771 W. 5th Ave., Columbus.

Oct. 30—California Section (Business Meeting) at Hacienda Hotel, Bakersfield. Secretary, Roy E. Dodson Jr., Supt. of Production, San Diego Water Dept., Balboa Park, San Diego.

Nov. 4–6—Virginia Section, at Hotel Roanoke, Roanoke. Secretary, E. H. Ruehl, R. Stuart Royer & Assocs., 15 W. Cary St., Richmond.

Nov. 9–11—North Carolina Section, at Washington Duke Hotel, Durham. Secretary, D. Y. Brannock, Director, Utilities Dept., Burlington.

Nov. 15–19—Florida Section, at Hillsboro Hotel, Tampa. Secretary, J. G. Simmons, Plant Supt., West Palm Beach Water Dept., Box 1311, West Palm Beach.

Dec. 3–5—Cuban Section, Havana. Secretary, Juan Berasategui, Civ. Engr., Calle K, No. 303, Apdo. 22, Vedado, Havana.

OTHER ORGANIZATIONS

Aug. 17–21—Short course on "Recent Developments in Water Bacteriology," R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: Chief, Training Program, 4676 Columbia Pkwy., Cincinnati 26, Ohio (or to USPHS regional office).

Sep. 7–11—Ion-Exchange Conference, sponsored by Oak Ridge National Lab., at Gatlinburg, Tenn. (attendance limited). Write: Prof. William Rieman III, Vice-Chairman, Ion-Exchange Conference, R. G. Wright Lab., Rutgers State University, New Brunswick, N.J.

Sep. 13–18—American Chemical Society, Atlantic City, N.J.

Sep. 15–18—International Conference for the Protection Against Corrosion of Structures and Equipment of Hydroelectric Power Plants, Belgrade, Yugoslavia. Write: Secretary, International Conference, Box 711, Belgrade, Yugoslavia.

Sep. 21–25—Instrument-Automation Conference & Exhibit, Instrument Society of America, International Amphitheater, Chicago, Ill. Write: H. S. Kindler, Director of Tech. & Educational Services, 313—6th Ave., Pittsburgh 22, Pa.

Sep. 28–Oct. 1—American Welding Society, Sheraton-Cadillac Hotel, Detroit, Mich.

Oct. 12–15—Federation of Sewage & Industrial Wastes Assns., Statler Hilton Hotel, Dallas, Tex.

Oct. 19–23—APHA Annual Meeting, Convention Hall, Atlantic City, N.J.

Oct. 19–23—ASCE Annual Convention, Hotel Statler, Washington, D.C.

Oct. 20–22—ASA National Conference on Standards, Sheraton-Cadillac Hotel, Detroit, Mich.

Nov. 29–Dec. 4—ASME Annual Meeting, Chalfonte–Haddon Hall Hotel, Atlantic City, N.J.

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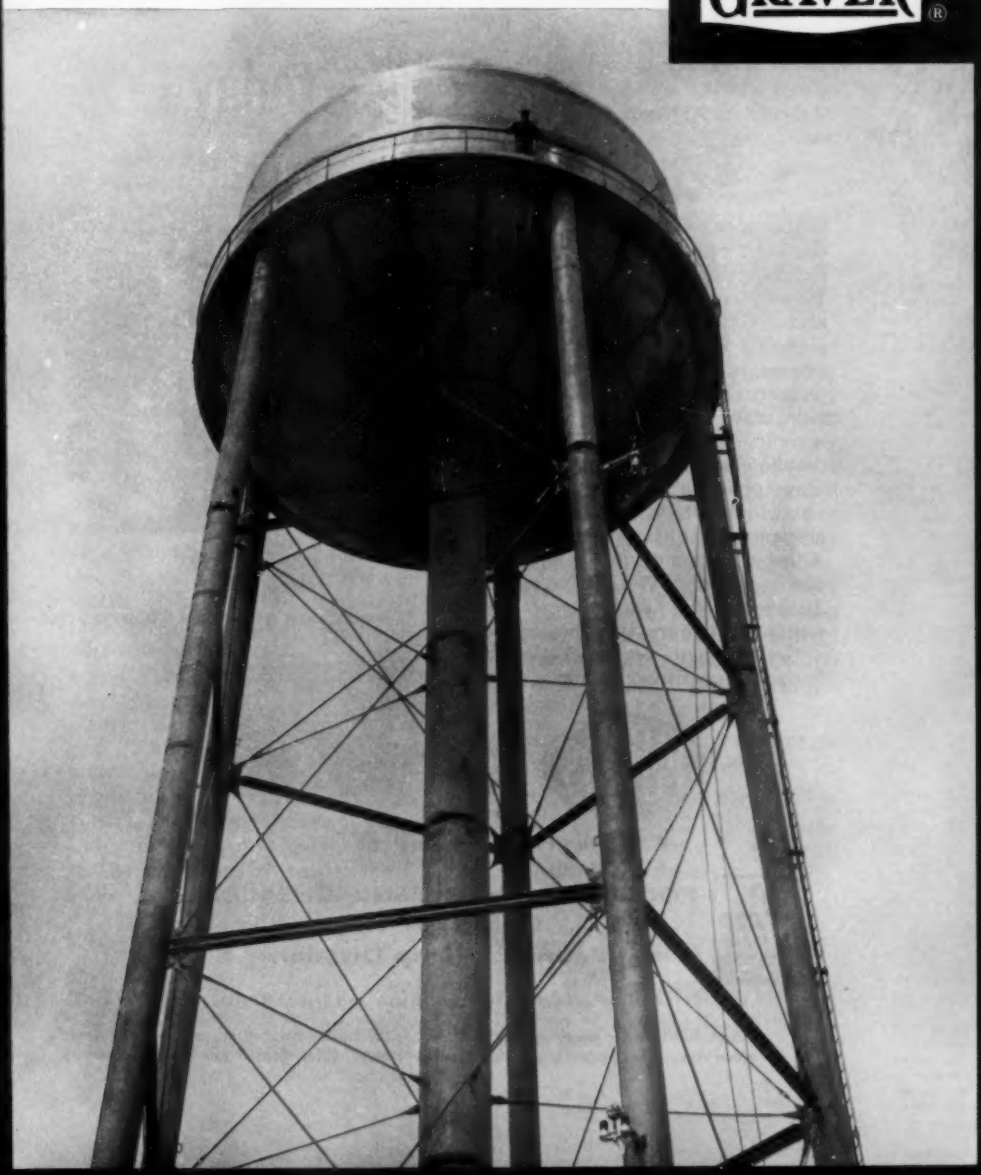

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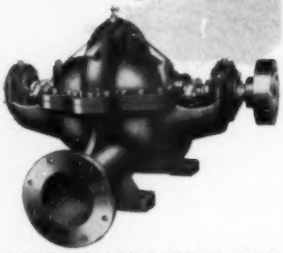

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Are plastics approved for drinking water? Yes... the National Sanitation Foundation at University of Michigan regularly test Ace Riviclor,® Ace-Ite,® Ace Supplex® and certain of our other brands of plastic pipe, and certify them non-toxic. These materials are odorless and tasteless.

Are plastics strong enough? Hundreds of water works and chemical plants (all very critical people) say *yes!* Plastic pipe is now available in several wall thicknesses for working pressure to 490 psi. It takes hard knocks, and resists accidental cutting and damage.

Where do I use it? Ace-Ite and Riviclor have been used for years in water and sewage works for feeding chemicals... chlorine, alum, ferrous sulfate, ferric chloride, etc. They outlast ordinary metals many times over.

Greatest future use is in service lines and small water mains, now under study. We've supplied miles of pipe for successful installations. If you haven't yet put some underground for test, it's time to start. Nothing takes the place of *personal* experience.

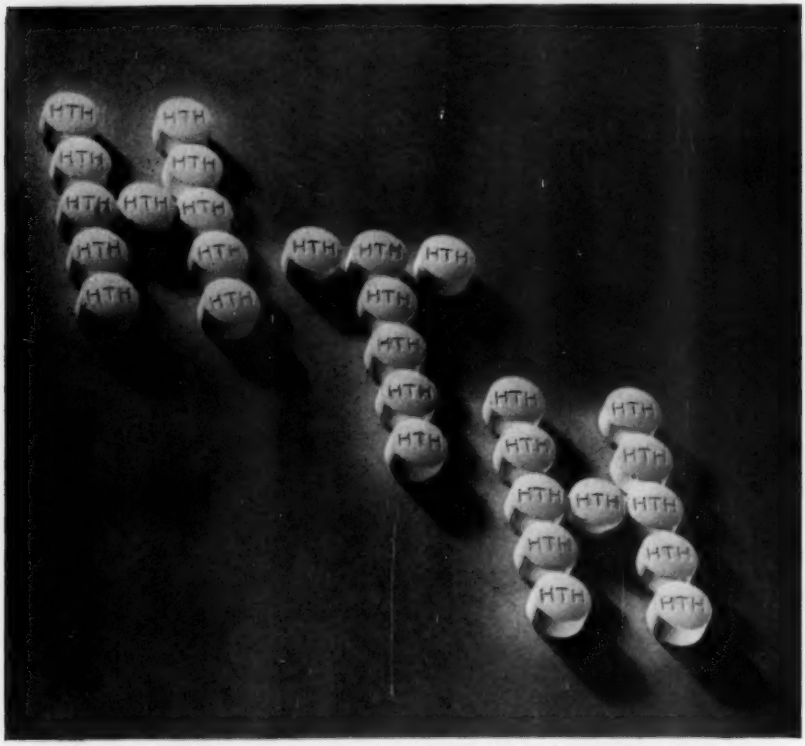
How can I dodge the pitfalls of "trial and error?" Go to a company that has no axe to grind... a company with wide experience in water works problems. We, for instance, supply *seven* different kinds of pipe for water and sewage works... with fittings and valves to match. And we've supplied a high percentage of the hard rubber water meter parts, rubber-lined ion-exchange tanks, molded chlorinator parts, rubber-lined intake lines, and chemical pumps now in use. For truly unbiased advice... backed by 100 years of experience... come to American Hard Rubber Company.

Free Selector Charts. 20 valuable pages ... comparable properties, chemical resistance, costs, etc., of 11 plastics and rubber materials.

Write today for Technical Bulletin CE-50W.

Ace-Ite®, Ace Riviclor® and Ace Supplex® are approved for drinking water.

ACE RUBBER & PLASTICS EQUIPMENT
BY AMERICAN HARD RUBBER COMPANY
DIVISION OF AMERACE CORPORATION
ACE ROAD • BUTLER, N. J.



for your protection, only genuine HTH Tablets are stamped HTH

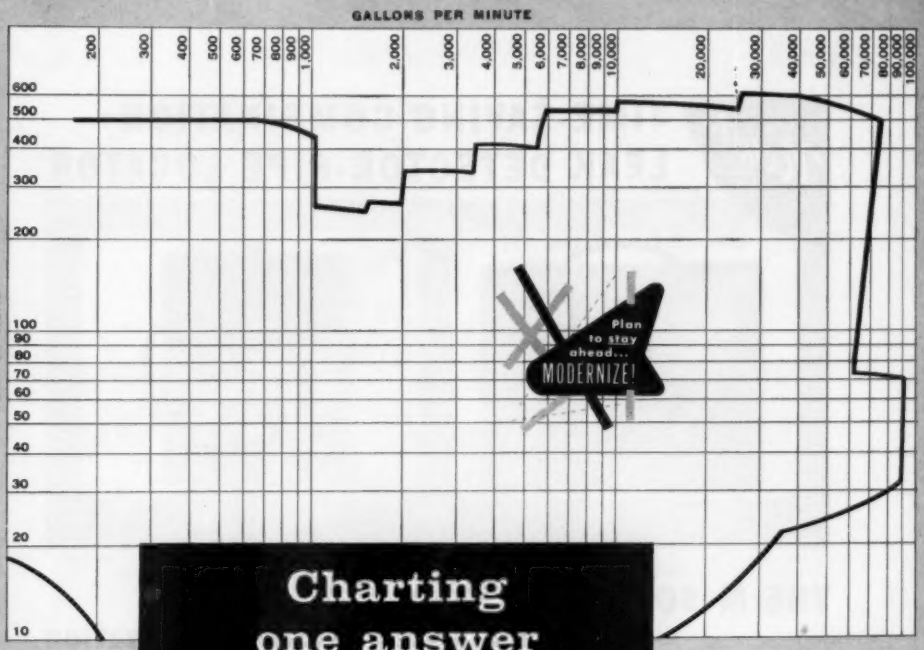
dry CHLORINE
safe, easy-to-use

For a slow, steady source of chlorine, use HTH Tablets, chlorine in its most modern form. Containing 70% available chlorine, HTH Tablets are conveniently packed in 100-lb. drums and in cases of twelve 3¾-lb. cans.

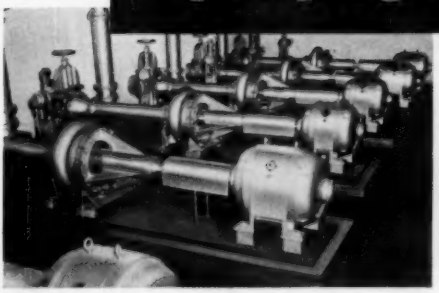
HTH® is a Trade Mark

OLIN MATHIESON CHEMICAL CORPORATION
CHEMICALS DIVISION • BALTIMORE 3, MD.

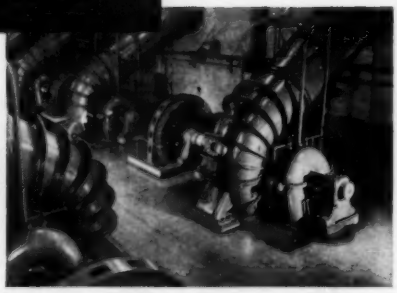
5557-A



Charting one answer for every pumping need



Auxiliary service is the job for six 10 x 8 A-C pumps. They are driven by Allis-Chalmers motors.



Main station application involves 12 A-C 72-inch Type SP pumps like that shown.

FROM the smallest auxiliaries to giant, main system pumps, the range chart for Allis-Chalmers pumping units covers practically every public works requirement. One-source equipment availability is a good reason why A-C should be given "first call" in modernizing the pumping facilities.

And complete line is only one "plus" for Allis-Chalmers. Teamed motors and control; standardization of parts and materials; engineering assistance and nationwide service are others.

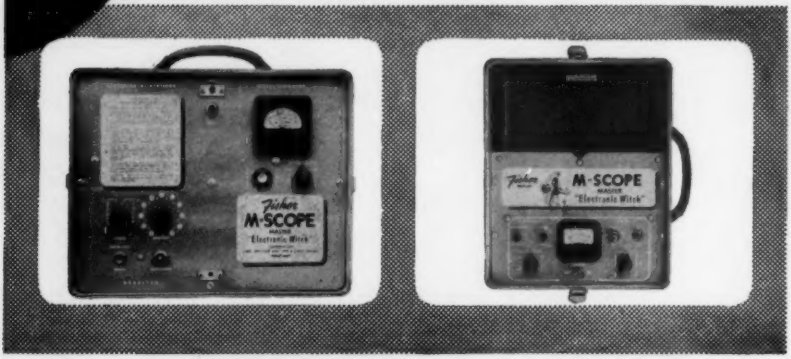
Whatever your need in centrifugal pumps, contact your representative or distributor. For additional information, write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-1023-PW

New!

TIME-$AVING COMBINATION LEAK DETECTOR-PIPE LOCATOR



THE M-SCOPE MASTER Electronic Witch Combination

You're looking at the much-talked-about **NEW M-Scope** . . . the only dual-purpose that **detects leaks and locates pipe.** Its rugged, highly efficient electronic circuit, plus ease of use and portability, make this instrument one of the most welcome contributions to the water works industry.

Quick Facts

For greatest convenience and reliability, the M-Scope MASTER is equipped with a **built-in battery tester** for instant checking of battery condition in the field or elsewhere.

WRITE TODAY FOR SPECIFICATIONS AND PRICE!

PIPE LINE EQUIPMENT
JOSEPH G. POLLARD CO., INC.
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PIPE LINE EQUIPMENT

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If it's from POLLARD it's the Best in Pipe Line Equipment

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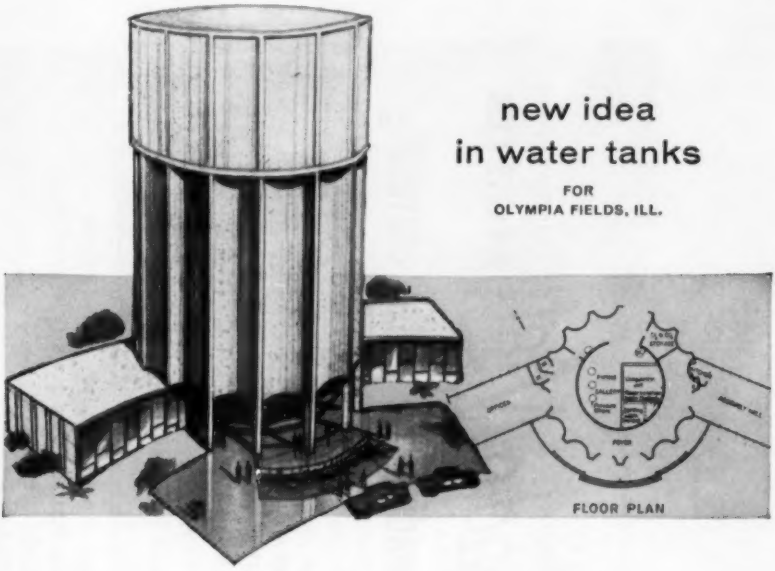


new idea in water tanks

FOR
OLYMPIA FIELDS, ILL.

modern concrete design puts "dead" space to work to provide attractive, useful municipal center!

The growing community of Olympia Fields solved more than one problem by choosing concrete for its water tower. The elevated water tank itself is prestressed concrete, 1-million gallon capacity. It is built for years of dependable, trouble-free service.

And supporting the tank on concentric walls of reinforced concrete gives an enclosure with plenty of room to house a compact treatment plant, plus second-floor storage for chemicals and department equipment. The fluted outside wall creates an attractive structure.

It is proposed that the wings will be added later, to be used for municipal offices and a large, pleasant assembly hall. (They would serve equally well as fire and police stations, civil defense or street department offices.) The result will be an efficient, integrated structure of architectural beauty.

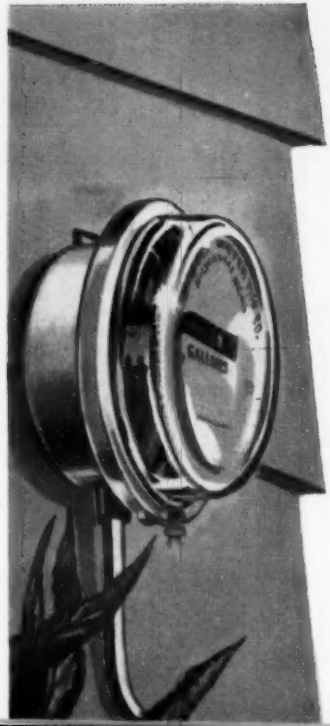
Engineers estimate that the combined building will save Olympia Fields real money—as much as $270,000 compared to the cost for separate facilities. And concrete will go on saving money. There will be little or no upkeep, ever. Concrete can't rust, doesn't need frequent painting. When America builds for beauty *and* economy . . . it builds with concrete.

Consulting Engineer: R. W. Robinson & Assoc., South Holland, Ill.
Architects: Wasserman and Cabanban, Assoc., Chicago, Ill.
Tank Design: The Preload Company, Inc., New York, N.Y.

PORTLAND CEMENT ASSOCIATION

A national organization to improve and extend the uses of concrete

MODERN concrete



New! BADGER Read-o-Matic* REGISTER

adds speed-reading to water metering

Here is the industry's first practical outdoor register — the Badger Read-o-Matic. Now meter reading routes can be completed in half the time — with no more wasted calls. Plus other important benefits such as:

• ***No more "lockouts"*** • ***No more in-house accidents*** • ***No more access problems*** • ***No more inconvenienced customers***

The new Badger Read-o-Matic means a modern meter reading system that your water department can have now — and opens a whole new realm of possibilities for the future. You'll want to read about them in our free new Badger Read-o-Matic folder.

*Pat. applied for in U. S. A. and foreign countries

Here's the big news behind the industry's first practical outdoor register

The Badger Read-o-Matic is powered entirely by the meter to which it is attached . . . works on an exclusive "pulse" principle. As water flows through the meter, the generator sends a pulse by wire to the Badger Read-o-Matic register outside for accurate recording.

Like our Badger meters, the Badger Read-o-Matic is precision-engineered — thoroughly tested by our trained water meter experts in the laboratory and in the field. Badger Meter products are the result of over 50 years of *specialized* water meter experience — products that excel around the world in accuracy, durability, dependability and low maintenance cost.

Send for free, colorful brochure that tells you all about the revolutionary Badger Read-o-Matic. For an actual demonstration, see your Badger representative or write us direct.

Badger Water Meters

Badger Meter Mfg. Co. • 4545 W. Brown Deer Rd. • Milwaukee 18, Wis.

AMERICAN FERROFILTER

Installation of "American" Ferrofilters and "American" Double Suction Split Case Pumps at Columbus, Indiana Water Plant • Consulting Engineers, Henry B. Steeg & Associates, Inc., Indianapolis, Indiana.

Independent tests and observations of "American" Ferrofilter operation at the Columbus, Indiana water plant show reduction to .15 ppm on 1.8 MGD loading/filter. (Units are rated 1.5 MGD.) Even on excess loading of 2.5 MGD/filter with all six wells on, iron reduction was still getting down to .2 ppm.

The "American" Ferrofilter is a contact filter that offers many advantages as a complete process or as a preliminary process—for the removal of iron, manganese, carbon dioxide, and other dissolved gases and odors, in one simple operation. It combines fundamental processes and design in an effective and economical treatment plant. Utilizes fine media in open aeration. Can be backwashed to remove any excess accumulation, leaving the filter in condition for another cycle. In most cases, it eliminates the need for a sedimentation tank or sand filter.

Write for Bulletin No. 252B or for specific information relating to your application.

Utilize our experience in engineering design and manufacture of field-proved equipment and pumps for water and waste treatment.

AMERICAN WELL WORKS

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112 North Broadway
AURORA, ILLINOIS

Pumping, Sewage Treatment, and Water Purification Equipment
RESEARCH • ENGINEERING • MANUFACTURING

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KENNEDY VALVE has a complete line of A.W.W.A. Standard Gate Valves . . .

. . . that conform to A.W.W.A. specifications in all respects

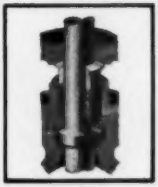
FIG. 58
- Inside Screw
- Non-Rising Stem
- Parallel Seats
- Bell Ends

FIG. 571X
- Inside Screw
- Non-Rising Stem
- Parallel Seats
- Mechanical Joint Ends

FIG. 561
- Inside Screw
- Non-Rising Stem
- Parallel Seats
- Flanged Ends

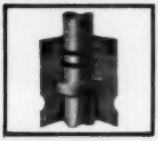
FIG. 566
- Outside-Screw-and-Yoke
- Rising Stem
- Parallel Seats
- Flanged Ends

Construction features . . .



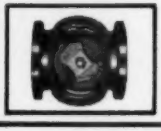
Conventional stuffing box

with adjustable gland has ample space for packing that conforms to Federal specification HH-P-106c. The bottom face of the stuffing box flange is faced smooth to form bearing surface for stem thrust collar.



O-Ring seals

once installed no adjustment of any kind is required. The top O-Ring is the dirt seal and the bottom O-Ring is the pressure seal.



Operating nut

is Higher Strength Cast Iron. The base flange, with arrow indicating direction to open, is shaped to permit access from ground surface to adjust gland nuts with an extension socket wrench.

KENNEDY A.W.W.A. Standard gate valves are designed specifically for use in water works systems. Conforming to A.W.W.A. Specifications, in several particulars these valves exceed these standards of strength and refinements of design.

While A.W.W.A. Specifications cover only bell end and flanged end non-rising stem valves, the KENNEDY line also includes outside-screw-and-yoke valves and a wide variety of pipe connections including: Bell Ends, Flanged Ends, Mechanical Joint Ends, Universal Pipe Ends, Asbestos Cement Pipe Ends, Screwed Ends, Ring-Tite Pipe Ends and Spigot Ends.

In addition to standard features, KENNEDY A.W.W.A. Valves have reduction gearing, gear cases, by-passes; indicators and rollers, tracks and scrapers available on 16" and larger sizes. Gearing is always furnished on 30" and larger valves.

KENNEDY VALVE MFG. CO.
ELMIRA, NEW YORK
VALVES
FIRE HYDRANTS

• WRITE TODAY FOR A.W.W.A. BULLETIN 561

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YOU'RE ON

EASY STREET

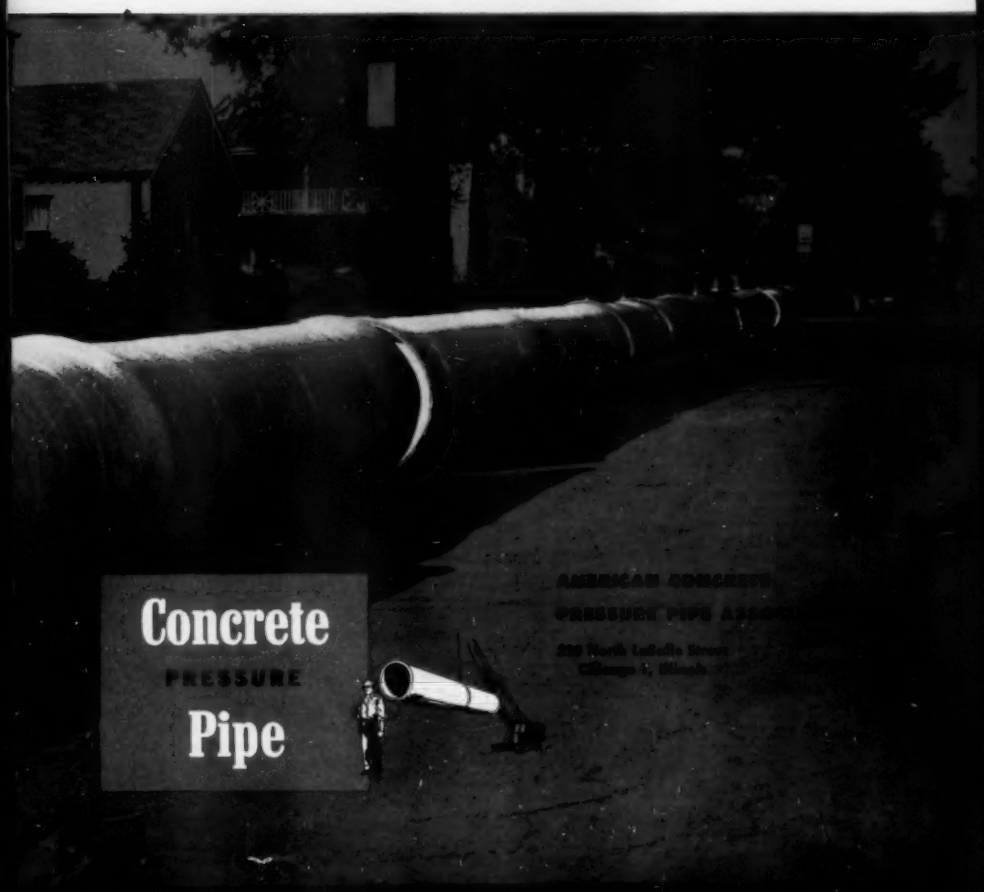
With Water Distribution Lines of

Dependable Concrete Cylinder Pressure Pipe

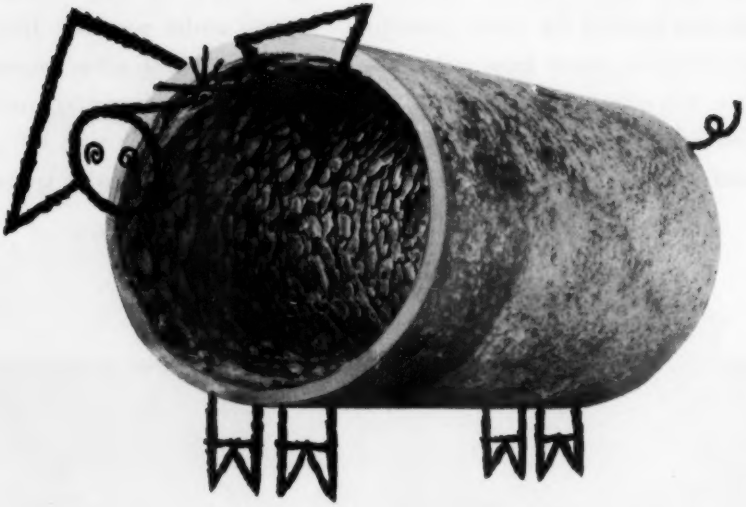
Concrete Cylinder Pressure Pipe has an unexcelled record for complete reliability. It is your community's best protection against the costly damage claims that can result from water line failure. It is also insurance against the expense and problems usually connected with the repair of water lines particularly in congested locations.

Further, Concrete Cylinder Pressure Pipe can be simply and efficiently tapped under pressure. This makes it easy to establish either service connections for an expanding community or cross connections with other lines in your water distribution system.

WATER FOR GENERATIONS TO COME



portrait of a power hog



When water flow capacities go down and pumping costs go up, the culprit is usually *tuberculation*. The way to deal with this power hog is right on his own ground — the inner surface of the water main. Here Calgon,® the simple and inexpensive way to deal with corrosion,† goes to work. By interposing a tough film between the metal surface and water, Calgon definitely controls corrosion.

Calgon treatment of the water is particularly effective after mechanical main cleaning because of its fast film-forming ability. Protection for freshly scored metal surfaces is quickly built up and easily maintained. Calgon treatment is as inexpensive as it is effective — a few ppm control tuberculation and other corrosion problems as well.

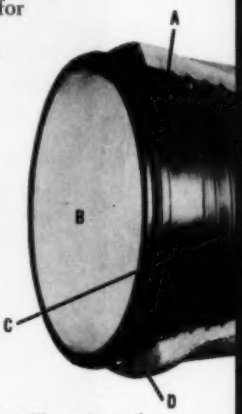
A letter or phone call will bring you more information on how Calgon can help. Or, an experienced Calgon engineer will be glad to make detailed recommendations on your specific problem.

CALGON COMPANY
DIVISION OF **HAGAN** CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PA.
In Canada: Hagan Corporation (Canada) Limited, Toronto

AMERICAN CONCRETE CYLINDER PIPE *provides...*

DEPENDABILITY with ECONOMY

This pretensioned concrete cylinder pipe embodies all of the qualities and characteristics sought by water works engineers for permanent water supply and transmission lines – strength, sustained high carrying capacity; trouble free service and unusually long life. When you select pressure pipe for your permanent water "growth lines," be sure to investigate American Concrete Cylinder Pipe, a superior product with an outstanding record of acceptance.



A. The steel cylinder provides a positive water seal or membrane as well as part of the total steel area required for internal stresses.

B. The smooth centrifugally applied mortar lining of a nominal ¾" thickness provides positive internal protection, sustained hydraulic capacity, and, **imparts rigidity and strength through "arching effect."**

C. Steel reinforcement rods, which together with the steel cylinder provide the total cross-sectional steel area required for the operating pressure specified, are wound under controlled tension and accurate spacing around the concrete lined cylinder, placing it under moderate compression.

D. In conjunction with the steel rod reinforcement along the entire surface of the cylinder, the application of a dense concrete coating produces, in effect, a **reinforced jacket** which affords additional structural strength as well as positive exterior protection.

American PIPE AND CONSTRUCTION CO.

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PORTLAND: 518 N. E. Columbia Blvd.— BUtler 5-2531
ALBUQUERQUE: P. O. Box 1782 — CHapel 7-0486
PHOENIX: American Concrete Pipe Co. (Subsidiary)
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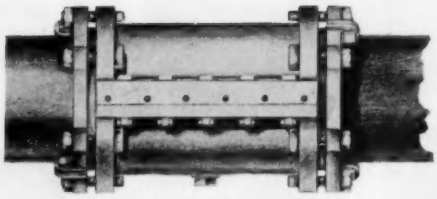
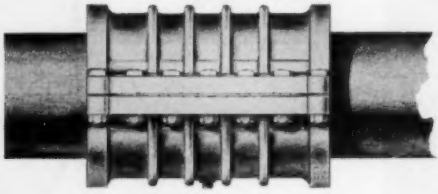


Mechanical Joint Repair Sleeve



Bell (Hub) End Repair Sleeve

INSTALL A SMITH SLEEVE

Smith Repair Sleeves are the answer to permanently repairing and quickly returning broken and cracked piping to service. Two types of Smith Repair Sleeves are available for installation on standard classes of cast iron pipe. Smith Mechanical Joint Repair Sleeves are produced in sizes 4″ thru 12″; Smith Bell (Hub) End in sizes 4″ thru 48″. Unskilled labor can speedily install Smith Mechanical Joint Repair Sleeves even in wet excavations. Bell End Repair Sleeves are most frequently installed with caulked lead joints. Smith Repair Sleeves reenforce the broken — cracked pipe and their service life equals the life of the pipe.

63

FIRE HYDRANTS · VALVES · SINCE 1896

THE A.P. SMITH MFG. CO.

EAST ORANGE, NEW JERSEY

put IDEAL

PERFORMANCE

into your **PUMPING**

for greater **ECONOMY and EFFICIENCY**

Perfect for any pumping problem, IDEAL Vertical Motors are designed and built to rigid standards of quality and performance for the ultimate in efficiency, economy and extended service. Squirrel Cage, Synchronous and Wound Rotor types in solid or hollow-shaft models are available with choice of bearings, bases, enclosures and insulations for any requirement. Drip-proof, splash-proof, weather protected and totally-enclosed construction for all atmospheric and climatic conditions. Write for bulletins 212 (15-125HP) and 219 (150HP and larger).

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SINCE 1903, AMERICA'S FINEST MOTORS, GENERATORS, MOTOR-GENERATOR SETS, SWITCHGEAR AND CONTROLS

SELF-EXPANDING CORK

THE JOINT MATERIAL THAT "GROWS" AFTER COMPRESSION
SELF-EXPANDING CORK IN JOINT
Normal Opening
JOINT COMPRESSED
CONTRACTED JOINT
Self-Expanding Cork Filler Expands Up To 50% Beyond Original Thickness

...keeps joints filled under maximum contraction

Specify and use Servicised SELF-EXPANDING CORK premolded joint filler in water and sewage treatment plants, canal linings and structures, outlet works, spillways and stilling basins in dams—and any other project where it is essential to keep the joints filled when contraction may open them up to more than original size.

Self-Expanding Cork Joint is formed from clean, granulated cork particles securely bonded together by an insoluble synthetic resin binder. It is specially treated to expand as much as 50% beyond original thickness. Fully compressible, non-extruding and resilient, Servicised Self-Expanding Cork is available in ½", ¾" and 1" thicknesses and lengths up to 10 ft.

Write for your copy of the new Servicised Catalog. It contains complete information on Self-Expanding Cork, as well as many other types of premolded joint fillers, and the Servicised line of hot and cold applied joint sealers we manufacture.

See our Catalog in Sweets.

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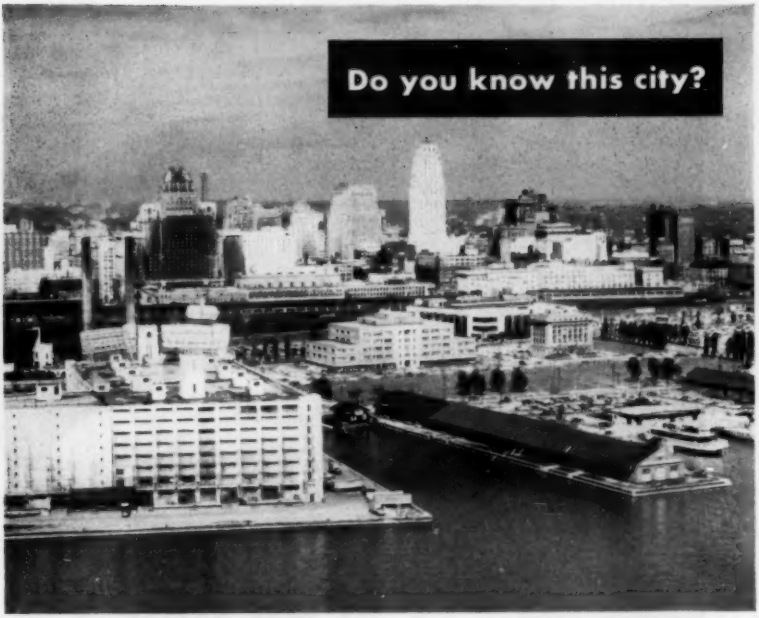

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maintain vital water requirements of...

Toronto. Key city of Canada, manufacturing capital, grain center, now a great new port of call for world-wide shipping on the St. Lawrence Seaway.

Toronto's vital water requirements rely on dependable De Laval waterworks pumps, standard of engineering efficiency for over half a century.

Write for your copies of De Laval Bulletins 1004 and 1005 giving data on these pumps

DE LAVAL *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY

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NEW!
EPON® 1001
INSIDE COATING

The most important potable water news in years!

. . . For all piping—metal, concrete, tile
. . . For any water condition
. . . For any practical flow rate, *and now*—
. . . Meets existing public health requirements

Among the toughest, most durable resins known to modern chemistry, Shell Epon 1001 is an ideal interior pipeline coating for potable water lines. It has an outstanding record of performance as a chemical-resisting coating for oil pipelines, tank interiors, and as a finish coating for appliances, trucks, and plant equipment exposed to corrosive fumes.

Conventionally cured coatings of Epon 1001 have truly remarkable adhesion, especially to metals, excellent resistance to impact, cavitation, and abrasion. Outstandingly resistant to water erosion, Epon 1001 interior pipe coatings have given years of service, even in difficult water areas, with no perceptible deterioration or contamination of supply.

Epon 1001 may be applied by brush, spray or pig. Setting takes place at room temperature within an hour or so. Curing time may be considerably shortened by the application of heat.

The best news of all is that Epon 1001 pipeline coating can reduce your maintenance costs, no matter what your potable water condition . . . and often enables you to supply higher purity water.

Contact your nearest Shell Chemical district office for complete information on this important new development. Your Shell Chemical district representative has all the facts you need to help you get started right away.

EPON puts the power in paint

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SHELL

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NOW—A REVOLUTIONARY NEW LOW-COST CONCEPT IN PIPE BUYING

Southern Pipe *Packaged Waterlines* offer you a brand new way to save money, cut red tape, eliminate worries. One order does it all—from pipe production, lining and coating, to trenchsite delivery. You buy one complete waterline package, delivered when you need it.

SOUTHERN PIPE *PACKAGED WATERLINES* GIVE YOU:

(1) pipe produced to your exacting specifications,
(2) from steel coil in our own pipe mill,
(3) cut precisely with NO random lengths,
(4) lined and coated at our plant,
(5) warehoused, if necessary, until you need it, and
(6) delivered to your trenchsite ready for placing in trench.

Packaged Waterlines from our warehouse stock of standard sizes are also available for immediate delivery.

Write for PACKAGED WATERLINES brochure today.

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USI Southern Pipe

DIVISION OF U.S. INDUSTRIES, INC.

P.O. BOX C • AZUSA, CALIFORNIA • CUmberland 3-7111 – EDgewood 7-1221

SP-25-59

Go ahead . . .
freeze it!

it's a
Calmet

No need to replace weather damaged water meters this winter, if you standardize on Calmet *now*. Calmet's the all-bronze, split-case, frost-proof-bolt meter that can take it.

When water freezes in a Calmet, the shear pins allow the case to separate, protecting both case and internal working parts. Now, without removing the meter from the service line, all you do is change the pins. A Calmet's as good as new again!

And that's *another* reason why Calmet maintenance cost is the lowest known.

WORTHINGTON
CALMET METER DIVISION
2301 SO. MAIN
FORT WORTH, TEXAS

There's no waste water from a V-notch

Why?

Because a V-notch Chlorinator needs no auxiliary water supply.

You can plan on clean, dry chlorinator rooms with no messy drain—no chlorine gassing back. And best of all... gone forever is the high cost of wasted auxiliary water.

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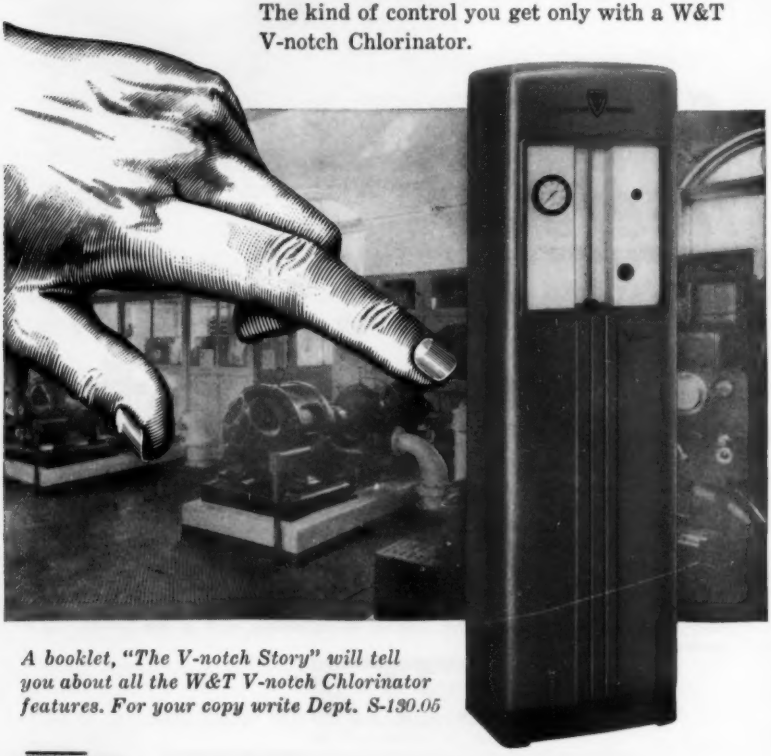

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Water Composition Changes in Air-Conditioning Equipment

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IN recent years the water supply industry has become all too aware of the tremendous increase in seasonal water demand brought about by the rapid growth of air conditioning. This demand has caused the widespread issuance of regulations requiring the use of water conservation equipment (*1*) whose use, in turn, gives rise to many water-caused operating problems.

With the increased use of cooling towers and evaporative condensers in small commercial air-conditioning installations, water-caused troubles are now plaguing businessmen who have had no previous experience with such problems, and they turn naturally to the local water supplier for help. Such appeals make it important that water supply chemists and operators become aware of the changes that can occur in circulating cooling waters and of the operating difficulties that can be caused by these changes.

Air-Conditioning Water Applications

Consideration of the typical water-using units in air-conditioning installations will show the basis for water composition changes which take place in such equipment. Although there are other types of air-conditioning systems in use, such as absorption refrigeration systems, the water problems inherent in the compression refrigeration system illustrated in Fig. 1 are also present in the other systems, even though they may vary in importance from one type of system to another.

Figure 1 shows all components of a typical central air-conditioning system. Not every system includes all of these components. Essentially, an air-conditioning installation takes heat from air that is to be circulated in an enclosed space and moves the heat for dispersal at some other location where it is less offensive.

Thus, in Fig. 1, a closed chilled-water system removes heat from the air, which passes through an air washer before entering the conditioned area. Heat picked up by the chilled water is transferred to the refrigerant by causing the latter to evaporate in the chiller. After compression of the refrigerant, the heat moves on to the cooling water in the refrigerant condenser. Finally, it is dissipated in the outside air by evaporation of a small percentage of the water in the cooling tower.

The air washer maintains the desired humidity in the conditioned air by humidifying it during the winter and by dehumidifying it during the summer. When the air is being humidified, water from open sprays is evaporated; when the air is being dehumidified, there is condensation of moisture from the air. Some air washers spray chilled water into the air, thus cooling and dehumidifying the air simultaneously. Others, like the one illustrated in Fig. 1, pass chilled water through a closed coil.

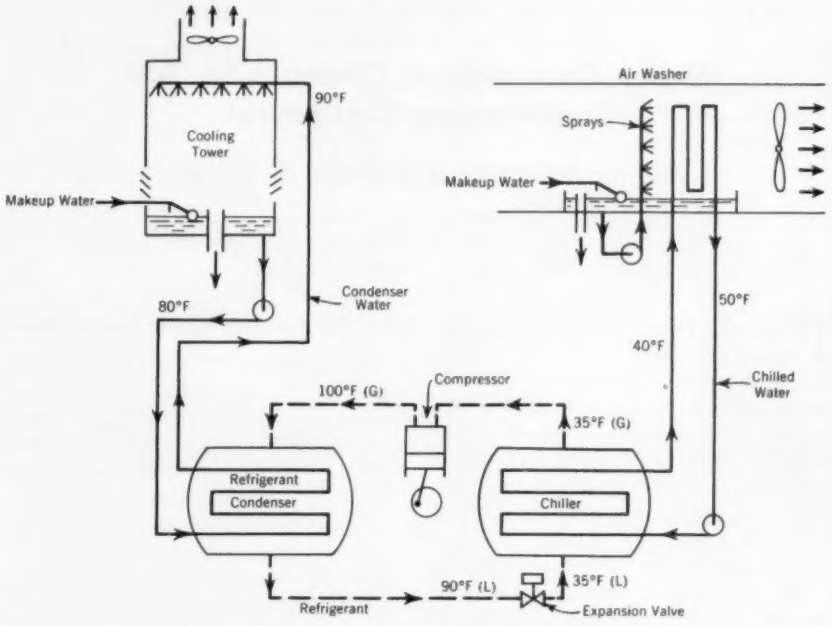

Fig. 1. Typical Central Air-Conditioning System

Not every system includes all the components shown above. This system has an air washer which maintains the humidity at an almost constant level the year round.

In the package air conditioner commonly used in smaller installations, there is no air washer. Both cooling and dehumidification are achieved by passing the air over coils containing cool refrigerant gas.

Once-Through Systems

When air-conditioning systems are cooled by once-through use of water,

whether from a public supply or from a private source, water-caused problems will be essentially the same as those in any piping system using the same supply. Corrosive waters will cause corrosion in the cooling system, and scaling waters will tend to form a scale.

Other than a small pickup of metal ions resulting from corrosion, or a slight loss of hardness and alkalinity resulting from scale formation, the water composition scarcely changes in once-through cooling systems. For example, with a corrosive Plainview, N.Y., well water having a pH of 5.8, passage through refrigerant condenser coils and piping increased the iron content of the water from 0.2 ppm to 0.4 ppm, and the copper content from 0.0 ppm to 0.4 ppm.

Closed Systems

In theory, no significant changes should be caused by circulating water in the closed chilled-water systems used in larger central air-conditioning installations. The amount of scale formation or corrosion resulting from substances dissolved in the water that initially fills such a system could not cause much harm. It is not ordinarily thought that there will be an appreciable amount of makeup water required in such systems.

Actually, however, large amounts of makeup water are needed in many of these systems because of water losses from a variety of causes, such as pump packing gland leakage. A study of 84 closed systems (*2*) showed that more than half of them required an amount of makeup water equivalent to the original volume of water in the system at least once a month. One system required about eight system volumes of makeup water per month. The more makeup water in closed systems, the greater the chance for changes in water composition. In chilled-water systems the accumulation of corrosion products is the most frequent change observed.

Air Washers

Air washers, sometimes called humidifiers, can perform two different functions. When they are humidifying the air, usually during cooler weather, the chemical changes in their spray waters are similar to those found in any evaporative system, as described in later sections of this article.

During warmer and more humid weather, however, air washers act as dehumidifiers and condense moisture from the air. The water in the equipment is constantly being diluted by the condensate and its composition approaches that of distilled water. Because large volumes of air, often containing appreciable amounts of carbon dioxide and sulfur dioxide, come into contact with the condensate during dehumidification, it is quite common for air washer waters in urban areas to develop low pH and thus become very corrosive. Table 1 shows a typical analysis of circulating water present in an air washer during dehumidification. The low pH, low solids content, and the presence of corrosion products should be noted.

Evaporative Equipment

Evaporation of some of the circulating water takes place in cooling towers, in evaporative condensers, and in air washers (when the latter are humidifying). The changes in circulating-water composition are similar in all of these devices. Although makeup water composition has some influence upon the problems that develop in circulating-water systems, it is quite possible to develop scale-forming con-

TABLE 1

Changes in Composition of Air Washer Water During Dehumidification

Water	pH	Concentration—*ppm*						
		Alkalinity as $CaCO_3$	Free Mineral Acidity as $CaCO_3$	Hardness as $CaCO_3$	Chloride as Cl	Sulfate as SO_4	Iron as Fe	Copper as Cu
Makeup	6.9	10	0	20	3	9	0	0
Circulating	4.3	0	1	3	0.4	81	5	30

ditions in an evaporative system when a very corrosive makeup water is used and, conversely, to develop severely corrosive conditions when using a scale-forming makeup water. Table 2 shows two such examples.

Scale Formation

In evaporative processes, dissolved solids from the makeup are concentrated. This, of course, tends to increase the scale-forming tendency in the absence of any other changes. In addition to the increased concentration of all dissolved solids, the scale-forming tendency frequently is further increased because the water tends to approach equilibrium with various gases present in the atmosphere. A makeup water with a high carbon dioxide content loses carbon dioxide on passage through a cooling tower and approaches equilibrium in the 5–10-ppm CO_2 range, and sometimes even lower. With this loss of carbon dioxide, the pH of the circulating water rises to a value higher than that of the makeup water so that the scale-forming tendency is further increased. The alkalinity increase resulting from evaporation further raises the pH.

In Table 3 typical analyses of circulated air-conditioning cooling waters, together with their makeup waters, illustrate increases in dissolved solids and pH. The Brewster, N.Y., analyses show no evidence that scale formed, but the Peoria, Ill., analyses illustrate an approximately equal loss of alkalinity and hardness caused by scale

TABLE 2

Changes in Water Characteristics in Cooling-Tower Operation

City	Water*	pH	Concentration—*ppm*					
			Alkalinity as $CaCO_3$	Free Mineral Acidity as $CaCO_3$	Hardness as $CaCO_3$	Calcium as $CaCO_3$	Chloride as Cl	Sulfate as SO_4
Bethlehem, Pa.	C, corrosive	7.7	10	0	10	8	4	1
	T, scaling	8.0	172	0	500	316	410	340
Lansdale, Pa.	C, scaling	7.5	158	0	172	114	13	25
	T, corrosive	3.7	0	125	2,200	1,220	215	4,300

*C, city; T, tower.

formation. As is often true, the scale formed was a mixture of calcium and magnesium carbonates rather than a pure calcium carbonate. The fact that analysis of a circulating water does show fewer scale-forming solids than would be expected at the concentration estimated from the ratio of the chloride concentration of the makeup water to that of the circulating water does not necessarily mean that scale has actually formed in the equipment. The precipitated material may be in the form of a nonadherent sludge rather than a scale. On the other hand, with a high-pH makeup water, such as a lime-softened water, circulation through evaporative equipment can result in absorption of carbon dioxide from the air, thus reducing the pH to less than that of the makeup (Table 4).

TABLE 3

Increase in pH and Solids Content After Evaporation in Cooling Towers

Water	pH	Concentration—*ppm*							
		Total Alkalinity as $CaCO_3$	Phenolphthalein Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Calcium as $CaCO_3$	Free CO_2	Chloride as Cl	Sulfate as SO_4	Total Dissolved Solids
Brewster, N.Y.									
City supply	7.3	147	0	198	122	13.5	12	33	235
Cooling tower	8.5	256	14	348	204	0	20	60	413
Peoria, Ill.									
City supply	7.3	314	0	439	253	31	23	136	608
Evaporative condenser	7.6	366	0	664	260	17	52	320	1,005
Theoretical*		710		994	572		52	308	
Apparent loss (or gain)		344		330	312			+16	

* 2.26 concentrations.

Other Changes

In addition to increased scale-forming tendencies described above, circulation of cooling water through a countercurrent flow of air produces other changes. The excellent air-water contact, deliberately provided in evaporative equipment for cooling purposes, also keeps the circulating water saturated with oxygen at all times. This means that, in the absence of any protective surface film, metals in contact with the water will tend to corrode. This tendency can be greatly accelerated. In urban areas generally, and elsewhere when local conditions are conducive, carbon dioxide, sulfur dioxide, and sulfur trioxide from flue gases are scrubbed from the air. Larson and Hettick (*3*) have reported pickup of sulfate and acidity from air by rain even in a rural environment. Occasionally other gases are present in air entering evaporative equipment and are scrubbed from it, affecting circulating-water composition.

Absorption of sulfur dioxide and trioxide from air causes formation of sulfuric acid, which neutralizes the natural alkalinity of water. In locations having a rather high sulfur dioxide

TABLE 4

Reduction of High pH in a Cooling Tower, Dallas, Tex.

Water	pH	Concentration—*ppm*					
		Total Alkalinity as $CaCO_3$	Phenolphthalein Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Chloride as Cl	Sulfate as SO_4	Total Solids
City	10.2	32	18	70	32.5	30	139
Cooling tower	8.3	184	10	986	630	610	2,248

concentration in the air and a low alkalinity in the makeup water, severely corrosive conditions develop in untreated circulating cooling waters (*4*). Under these circumstances, circulating-water pH values as low as 2.5 have been observed, and 3.0–3.5 is not at all unusual. These waters also contain relatively high concentrations of metals corroded from the system. Copper is generally found only in low concentrations because it plates out on ferrous surfaces. In cooling systems that make use of untreated corrosive waters, copper-plating of steel piping, cast-iron pump housings, and thermometer wells are common.

Table 5 shows analyses of some untreated circulating cooling waters from urban areas. Comparison of the composition of makeup waters with corresponding circulating waters shows that the cause of the low pH is the absorption of sulfur oxides. In each example, the sulfate-chloride ratio in the circulating water increased substantially over that in the makeup water. At the same time, alkalinity decreased, often by an amount almost equivalent to the increase in the sulfate over that expected to result from evaporation.

As a matter of interest, if the amount of sulfur dioxide in the air is known, it is possible to calculate roughly its effect upon circulating-water composition from the makeup water alkalinity and the known operating characteristics of cooling towers. For example,

TABLE 5

Changes in Composition Causing Highly Corrosive Waters in Urban Cooling Towers

City	Water	pH	Concentration—*ppm*								
			Total Alkalinity as $CaCO_3$	Free Mineral Acidity as $CaCO_3$	Total Hardness as $CaCO_3$	Calcium as $CaCO_3$	Chloride as Cl	Sulfate as SO_4	Fe	Cu	Zn
Baltimore, Md.	city	8.0	46	0	64	48	8	14	0	0	0
	tower	3.2	0	120	880	660	116	1,060	28	1.4	3
New York, N.Y.	city	6.9	10	0	20	14	3	9	0	0	0
	Tower A*	3.2	0	44	680	410	72	520	33	3	
	Tower B	3.6	0	42	320	310	138	2,200	28	3	380
Philadelphia, Pa.	city	7.1	50	0	174	96	15	128	0	0	0
	tower	5.1	60	0	1,000	460	100	441	31	60	17
Richmond, Va.	city	8.3	26	0	57	42	15	37	0	0	0
	tower	4.1	0	1	1,716	1,040	610	1,820	53	5	trace

* Analysis of greenish stalactites at a number of leaking threaded joints on this cooling tower showed them to be 98 per cent copperas ($FeSO_4 \cdot 7H_2O$).

Greenburg and Jacobs (*5*) reported that the sulfur dioxide concentration in the air in New York (Manhattan) during the May–October air-conditioning season varies from 0.01 to 0.80 ppm, and averages 0.10 ppm. If a typical summer daytime air temperature of 80°F is assumed, this concentration corresponds to an average of 11 g of sulfuric acid per 1,000,000 cu ft of air.

The average cooling tower and evaporative condenser design calls for air passage of about 300 cfm per ton of refrigerating capacity. Therefore, during 1 ton-hr of operation 0.198 g of sulfuric acid passes through this equipment, and about 2.07 gal of makeup water is added to replace 1.8 gal lost by evaporation and 0.27 gal lost by windage or "drift" (droplets of liquid water carried out of the equipment by the air stream).

New York's Catskill supply contains about 10 ppm alkalinity or 0.038 g/gal (as $CaCO_3$). With this supply, the makeup water introduced in 1 ton-hr of operation contains only enough alkalinity to neutralize the sulfuric acid equivalent entering the equipment during 0.39 ton-hr of operation. Because these units are good air scrubbers, most of this acid is dissolved by the water. In other words, under average summer air pollution conditions in Manhattan, the sulfur dioxide that can be absorbed in a cooling tower or evaporative condenser in 1 ton-hr of operation is enough to neutralize $2\frac{1}{2}$ times as much alkalinity as is introduced in the makeup water during that time. Thus, one would expect that untreated circulating cooling water would develop extremely low pH values. Table 5 shows several examples confirming this expectation. At such low pH values corrosion failures within a few months are not uncommon.

TABLE 6

Effect of Cooling-Tower Location on a Single Building on Composition of System Water

Sample Source	pH	Concentration—*ppm*								
		Total Alkalinity as $CaCO_3$	Free Mineral Acidity as $CaCO_3$	Total Hardness as $CaCO_3$	Calcium as $CaCO_3$	Chloride as Cl	Sulfate as SO_4	Fe	Cu	Zn
City supply	7.5	136	0	184	124	16	47	0	0	0
Tower near stack	4.3	0	2	860	780	931	3,500	250	<1*	<1
Tower away from stack	8.3	182†	0	761	716	205	950	0.1	<1	<1

* Cast-iron parts showed copper plating.
† Calcium carbonate scale formed in the condenser.

Even in communities that have rather hard, high-alkalinity waters, local conditions can make circulating waters corrosive. One example of this is shown in Table 6, which gives analyses of makeup water and cooling-tower water from a factory building in Lancaster, Pa. There were two cooling towers on the same roof of the factory. Although the city water was hard and alkaline and would normally be expected to form scale after being concentrated by evaporation, the water in

one of the cooling towers became very corrosive within a short time and the water in the other formed scale.

Investigation showed that the first cooling tower was located within 15–20 ft of a smokestack, which terminated on a level with the louvers through which air was drawn into the cooling tower. Thus, flue gases were being thoroughly scrubbed by the circulating water in the tower. The other cooling tower was at some distance from the stack and, because less contaminated air entered, behaved as would be expected (*6*).

Unexpected Changes

Once in a while the change in cooling water composition as a result of gases scrubbed from the air is unexpected. In one cooling tower located in a city that normally develops the low pH conditions shown in Table 5, severe corrosion of copper was observed in a condenser cooled with untreated water, but the pH did not drop as expected. Cooling-water analyses showed that there had been sulfur dioxide pickup, as expected, but, surprisingly, ammonia had also been scrubbed from the air (Table 8) and had caused the attack on the copper tubes. It was found that ammonia was discharged from a nearby exhaust system and was drawn into the cooling tower.

TABLE 7

Formation of Sulfate Scale in Philadelphia Cooling-Water System

Data Type	pH	Concentration—*ppm*				
		Total Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Calcium as $CaCO_3$	Chloride as Cl	Sulfate as SO_4
Actual						
City supply	7.0	42	180	102	23	110
Evaporative condenser	7.0	84	932	288	402	480
Theoretical at concentration of 17.5 times		735	3,160	1,785	402	1,930
Apparent loss		641	2,228	1,497		1,440

When makeup water has a moderately high sulfate content, further sulfate increase resulting from scrubbing of sulfur dioxide and sulfur trioxide from the air can result in calcium sulfate scale formation. This can happen even at fairly low pH, and is important from a practical viewpoint, because it is more difficult to remove sulfate scale than to remove calcium carbonate scale. Table 7 shows an analysis of circulating water from an evoporative condenser than was depositing calcium sulfate scale.

Softened makeup waters have a tendency to develop higher pH levels when concentrated in evaporative equipment as a result of conversion of some sodium bicarbonate to sodium carbonate. Although oxygen-saturated soft cooling waters are generally corrosive, the higher pH values can cause particularly severe corrosion of some

TABLE 8

Ammonia Pickup and Other Changes in a Cooling Water

Sample Source	pH	Concentration—*ppm*								
		Total Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Calcium as $CaCO_3$	Chloride as Cl	Sulfate as SO_4	Ammonia as NH_3	Fe	Cu	Zn
City supply	6.8	10	20	14	3	8	0	0	0	0
Cooling tower	7.4	24	58	36	11	120	52	0	1	14

metals. An aluminum cooling tower in South Orange, N.J., was severely pitted by the water analyzed in Table 9. It should be noted that dissolved aluminum was found in the circulating water. Very soft, highly alkaline waters are aggressive to wood in cooling towers.

In addition to the changes in chemical composition brought about by evaporation and by reaction with acid or alkaline gases absorbed from the air, circulating waters also scrub many solids from the air, including bacteria, algae spores, and airborne dirt, all of which have significant effects upon the operation and life of air-conditioning equipment.

Growth of algae and of slime-forming bacteria at heat-exchange surfaces in circulating-water systems seriously interferes with cooling. Airborne dirt can result in accelerated localized corrosion of metal cooling-tower pans, and in damage to moving parts, such as scoring of pump shafts and excessively rapid wear of mechanical seals.

Changes in Supply

In connection with the influence of makeup water composition upon the operation of water conservation equipment in air conditioning and other cooling services, changes in municipal water supply resulting from a new water source or from new treatment processes can affect both the nature of problems encountered in evaporative cooling equipment and the quantities of water used. There are, of course, routine seasonal changes in surface water supplies. In some communities, however, reserve supplies, from older wells or from interconnections with other public systems, are brought into use at times of high demand. These reserve supplies may be quite different

TABLE 9

Increase in pH and Other Changes With Softened Makeup Water

Sample Source	pH	Concentration—*ppm*					
		Total Alkalinity as $CaCO_3$	Phenolphthalein Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Chloride as Cl	Sulfate as SO_4	Al
Softened city supply	8.3	125	1	1	25	62	0
Cooling tower	9.2	1,380	198	0	337	910	6

in composition from the normal supply. When, as is usual, this high-demand period coincides with the air-conditioning season, cooling water problems in that part of the community receiving the reserve supply will correspond more closely with those expected from a water of the reserve supply composition rather than with those expected from the regular supply.

The analyses in Table 10 show typical examples of both the wide range of seasonal change in water composition at a single location and the great differences in composition of two different supplies being furnished in the same city on the same day.

In another town the normal public supply was quite hard and would have resulted in rapid scale formation in evaporative cooling equipment, but the summer supply was very soft so that corrosion was the actual operating problem found.

Because minimizing scale formation involves, among other steps, using a continuous bleed, or discharge of a small percentage of circulating water to the sewer, softer makeup waters reduce water consumption in air-conditioning systems. Thus, substitution of a softer supply during warmer weather or softening of a municipal supply, in addition to minimizing scale formation difficulties for operators of cooling equipment, should reduce water consumption if operation of the equipment is properly adjusted to take advantage of the softer makeup.

TABLE 10

Variations in Water Composition in a Single Community, 1958

Location	Date	pH	Concentration—*ppm*					
			Total Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Calcium as $CaCO_3$	Chloride as Cl	Sulfate as SO_4	Total Dissolved Solids
East	Apr. 7	7.0	56	120	80	9	44	148
	May 9	7.1	68	126	86	12	45	165
	Aug. 5	6.9	120	210	138	18	48	241
West	May 9	7.3	250	308	140	27	31	371

Cooling-Water Treatment

The numerous methods available for the treatment of once-through and circulated cooling waters for scale, corrosion, slime, and algae control have been referred to in numerous publications (*7–12*). The authors do not intend to review such methods in this article.

It is important to keep in mind that, although there is a chemically best method of treatment for any particular water, such factors as design, location, and size of equipment, operating cycle, quality and quantity of personnel available, and cost considerations frequently make necessary the use of a less than perfect treatment method for a system (*13*). In view of these considerations and of the variety of treatment methods available, cooling-water treatment has become a highly specialized field. Inquiries regarding cooling-water treatment are best referred to industrial water treatment specialists who handle such problems.

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Minimum Potable Water Supply Requirements in Civil Defense Emergencies

Office of Civil & Defense Mobilization

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THIS article recommends minimum requirements for the quantity and quality of potable water to be provided during a national emergency. Local officials should determine now the most urgent needs for potable water immediately after an enemy attack or natural disaster. Preattack preparation to meet these needs should be made. In an emergency, medical-care water needs will be predominant.

Hospitals and other medical-care facilities must be given the highest priority on available potable water supplies. Of almost equal importance are the potable water requirements of disaster workers and persons being cared for at mass care centers or other welfare installations. If the general public has been adequately informed and prepared for neighborhood self-protection, persons still occupying homes and apartments after an enemy attack should be able to survive the first 14 days on stored supplies of potable water and other fluids (*1*). During this time, local officials will have to augment the supplies of potable water and arrange for later distribution after this period.

Quantity Requirements

Hospitals and other medical-care facilities. Water utility services should be prepared to provide potable water to existing and emergency hospitals, first-aid stations, and other medical facilities as soon as the attack situation permits. During the first 10 or 12 hr postattack, the quantity of water made available to these places should be not less than 5 gal per casualty treated. Most of this will be required at facilities conducting the sorting of casualties and surgical procedures. During the first 12 hr, and as hospitals fill up, the supply of water should be increased to provide at least 15 gal per patient per 24 hr. As medical services in hospitals are extended, still larger quantities of water will be needed to allow for cleaning, essential laundry work, and for use at sanitary facilities. This will require at least 25 gal per patient per 24 hr. Water utilities should be prepared to meet these requirements by emergency restoration of treatment works and distribution systems or by development of auxiliary supplies.

Mass care centers and other welfare installations. Where both lodging and emergency feeding are provided in a single facility, at least 5 gal per person should be supplied within the first 10–12 hr postattack, and 10–15 gal per person per 24 hr thereafter, if fallout conditions permit. The important

need in the first 12 hr will be at feeding facilities. Where lodging and feeding facilities are separate, the immediate requirements at lodging centers will be 2 gal per person per 24 hr for drinking and hand and face washing. Water requirements for cooking and sanitation at mass feeding stations will be at least 3 gal per person during the first few postattack hours of operation, and at least 10 gal per person per 24 hr after the first half day.

Where sewer facilities are available at the emergency lodging location and toilet flushing is permitted, the total water requirement (including drinking, feeding, and sanitary uses) will be at least 25 gal per person per 24 hr.

Households. Residents in homes and apartments will require supplementation of their stored supplies within a few days after the start of a national emergency, although, because of radioactive fallout, stored supplies may have to suffice for 14 days or more. In most instances, 5–15 gal per person per 24 hr is sufficient for drinking, cooking, and cleansing purposes. Where the sewer system is intact and toilet flushing is permitted, up to 25 gal per person per 24 hr will be needed to maintain sanitary conditions in the neighborhood.

Control of Special Weapons Contaminants

Biological and chemical warfare agents can constitute a serious hazard to emergency water supplies. Chemical agents can be readily detected in raw water supplies by detector kits that are available to water utilities (*2, 3*) through federal procurement (*4*).

Biological warfare agents cannot be identified as rapidly as chemical agents. The most rapid means now available employ the membrane filter technique of isolation and incubation, which requires from 8 to 12 hr for an indication of results. Emergency water supplies must be heavily chlorinated when biological warfare is suspected. The degree of chlorination and other treatment to be required is dependent upon both the nature of the raw supply and the use to which the water will be put. In disasters, however, all untreated water should be considered contaminated, and larger initial doses of chlorine should be used until bacteriological tests and general security conditions indicate that dosages may be reduced.

Emergency water supplies may have been contaminated by radioactive substances; therefore, the supplies should be monitored for radiation (*5–7*).

Hospitals and other medical-care facilities. When emergency or auxiliary water sources must be used to supply medical facilities, a good quality from the chemical and physical standpoint (turbidity, color, and minerals) must be assured, as well as bacteriological safety. If possible, water meeting minimum standards of chemical content (*8*) should be selected as emergency water sources. In preattack selection of possible emergency sources, the quality of water that can be obtained with the proposed facilities for emergency treatment should be checked for acceptability by local health services. Mobile water filtration units with chlorinators should be available to meet the water supply requirements of hospitals and other medical-care facilities when well supplies are not available and surface water supplies must be used.

Mass care centers and other welfare installations, and households. Bacteriological safety is the primary consideration in the quality of emergency water supplies for disaster workers, mass care centers and other welfare installations, and private homes. At the same time, sufficient attention must be given to taste and odor, so that the public does not look for a better-tasting but unsafe supply. Bacteriological safety can be obtained with chlorination of reasonably clear waters of neutral or acid pH at such a rate that 30 min after dosing there will be a free chlorine residual of not less than 5 ppm. Where biological warfare can be discounted, or where treatment by flocculation, sedimentation, and filtration is provided, the dosing rate may be reduced so that the residual after 30 min will be not less than 2 ppm in waters of neutral or acid pH.

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Water Analysis by Neutron Activation

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OVER the years, public health personnel have continuously sought to learn more about the quality of drinking water. Neutron activation analysis, based upon controlled exposure of samples in a nuclear reactor, may considerably broaden and extend the knowledge about elements in water. Investigations of the feasibility of this procedure were initiated in 1956 by Seal, Mills, and Terrill (*1*). The basic principles of the technique, and the data obtained from its application to drinking waters from seven geographical areas of the United States, are summarized.

Basic Principles

Neutron activation serves as an analytical technique because atoms of most elements, when irradiated with slow neutrons, give rise to radioactive species of the same element. This technique may be compared to conventional colorimetric analysis, in which the ion to be determined is made to react with a chromogenic compound to yield a colored endproduct. The color identifies the ion and, within limits, is a measure of its concentration. In activation analysis, the reagent is the bombarding neutron, the target material is the other reactant, and the radioisotope formed corresponds to the colored endproduct. The radioactive properties identify the element; the quantity of radioactive material is a measure of its concentration (*2*).

General Discussion

The first step in the procedure is the exposure of the water sample to neutron bombardment. This is usually accomplished by inserting the sample into a nuclear reactor, in which a copious supply of *slow* (*thermal*) neutrons is available. A typical reaction brought about by such bombardment involves Cl^{37}, a stable isotope of chlorine. In this reaction, a neutron (n) is captured, a gamma photon (γ) ejected, and the radioisotope Cl^{38} results. The reaction may be described as:

$$Cl^{37} + n^1 \rightarrow Cl^{38} + \gamma$$

often abbreviated as:

$$Cl^{37}\ (n, \gamma)\ Cl^{38}.$$

Other typical reactions in water analysis include:

$$Na^{23}\ (n, \gamma)\ Na^{24}$$
$$Al^{27}\ (n, \gamma)\ Al^{28}$$
$$Mn^{55}\ (n, \gamma)\ Mn^{56}$$
$$A^{40}\ (n, \gamma)\ A^{41}.$$

Reactions involving other nuclear particles and radiations are also possible, but their occurrence is generally not of importance in water subjected to slow neutron bombardment.

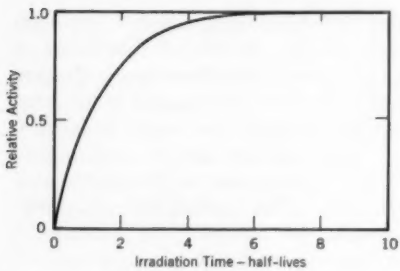

Fig. 1. Relationship of Induced Activity and Irradiation Time

For practical purposes, maximum activity is reached after an irradiation period of 6–8 half-lives.

Identification of Radionuclides

Each radionuclide induced in a water sample by neutron reactions possesses certain characteristic properties. Establishment of these properties leads to ready identification of the induced radionuclide (*3*). This information, in turn, establishes the presence of certain stable elements in the sample. In this sense, neutron activation is qualitative.

The identifying characteristics of a radionuclide include its half-life and the type and energy of its emissions. The half-life can be determined from the beta and gamma counts. Beta energies can be estimated from absorption studies, gamma energies from scintillation spectroscopy (*4*). In the identification of induced radionuclides in irradiated water samples, gamma scintillation spectroscopy has proved to be the method of choice.

Decay characteristics (*5*) for radionuclides investigated in this study are listed in Table 1. Although the establishment of these characteristics alone would theoretically make identification possible, chemical separations often serve as a valuable adjunct. In addition, identifying characteristics are more readily and easily determined in separated fractions.

Quantitative Analysis

Because the total activity of a particular radioisotope in an irradiated sample is a measure of the amount of the stable element from which it was produced, neutron activation analysis can be made quantitative. A number of factors, however, govern the quantitative relationship. In water samples, the induced radioactivity is directly proportional to: the concentration of the stable element from which it originated, the probability of the element for activation, and the rate of neutron bombardment.* The induced radioactivity also depends upon the relative abundance of the stable isotopes in a given element. Sodium, for example,

* The probability or cross section of a given isotope for activation is expressed in barns; one barn equals 10^{-24} sq cm. The rate of neutron bombardment is expressed in terms of a flux, usually given as the number of neutrons per square centimeter per second.

has only one stable isotope, Na^{23}. Thus, every atom of this element, on capturing a neutron, yields the radioactive species Na^{24}. The element magnesium, on the other hand, has three stable isotopes: Mg^{24}, Mg^{25}, and Mg^{26}. On capturing a neutron, stable Mg^{24} becomes Mg^{25}, which is also stable. technique, and its frequency of occurrence is directly dependent upon the relative abundance of Mg^{26} in naturally occurring magnesium.

Isotopes in Water

The activation technique is ideally suited to the analysis of impurities in water. Oxygen, for example, has three stable isotopes: O^{16}, O^{17}, and O^{18}. Of these, only O^{18}, which constitutes an extremely small fraction ($\cong$0.2 per cent) of the naturally occurring element, yields a radioactive product

TABLE 1

Characteristics of Typical Radionuclides Induced by Thermal-Neutron Irradiation of Water

Radionuclide	Half-Life	Radiation Energies—*Mev*	
		Beta	Gamma
A^{41}	1.8 hr	1.20, 2.48	1.29
Al^{28}	2.3 min	2.87	1.78
As^{76}	26.4 hr	2.97, 2.41, 1.76	0.56, 0.65, 1.21
Ba^{139}	84.0 min	2.38, 2.23, 0.82	0.16
Br^{82}	35.9 hr	0.44	0.55, 0.62, 0.70, 0.78, 0.83, 1.04, 1.32, 1.48
Ca^{45}	164.0 days	0.25	none
Cl^{38}	37.3 min	4.81, 2.77, 1.11	2.15, 1.60
Cu^{64}	12.8 hr	electron capture, 0.57, (0.66)	0.51,* 1.34
I^{128}	25.0 min	2.12, 1.67	0.46
K^{42}	12.5 hr	3.55, 1.99	1.53
Mn^{56}	2.6 hr	2.81, 1.04, 0.65	0.85, 1.81, 2.13
Mg^{27}	9.5 min	1.75, 1.59	0.83, 1.02
Na^{24}	15.0 hr	1.39	1.37, 2.75
P^{32}	14.2 days	1.71	none
Pa^{233}†	27.0 days	0.15, 0.26, 0.57	0.313, others
Rb^{86}	18.7 days	1.78, 0.71	1.08
Sb^{122}	2.8 days	0.74, 1.40, 1.97	0.56, 0.69, 1.14, 1.26
Sb^{124}	60.9 days	2.32, 1.60, 0.97, 0.61, 0.24	0.60, 0.65, 0.71, others
Si^{31}	2.6 hr	1.47	1.26 (weak)
Sr^{87m}‡	2.8 hr	isomeric transition	0.39§
Zn^{69m}‡	13.8 hr	isomeric transition	0.44§

* Annihilation gamma following positron emission.
† Produced by the reaction:

$$Th^{232}(n, \gamma)\ Th^{233} \xrightarrow[22.1\ \text{min}]{\beta^-} Pa^{233}.$$

‡ The letter *m* on radionuclides indicates an isomeric state.
§ Gamma photon accompanying isomeric transition.

Similarly, Mg^{25} also yields a stable product. Mg^{26}, however, on capturing a neutron, becomes Mg^{27}, a radioactive isotope. Thus, of these three possible reactions, only the last is of importance in the neutron activation

under thermal neutron bombardment. Furthermore, this product, O^{19}, has such a short half-life (29.4 sec) that it disappears rapidly. Of the hydrogen isotopes, only H^2 yields a radioactive product. As does O^{18}, H^2 constitutes an extremely small fraction of the natural element (≅0.015 per cent) and has a very small activation cross section. As a result, little radioactivity results from neutron irradiation of "pure" water itself.*

Irradiation Period

The number of radioactive atoms produced by neutron bombardment is also directly proportional to the period of irradiation. During irradiation, however, a certain fraction of these atoms decays. The net result—that is, the relationship between the period of irradiation (expressed in units of half-life) and the quantity of induced radioactive material—is influenced by both these factors (Fig. 1). It can be seen that the production of significant quantities of a radioactive material with a long half-life requires a long irradiation period. Common practice is to irradiate samples for at least one half-life of the radionuclide under investigation. For practical purposes, maximum activity is reached after an irradiation period of 6–8 half-lives.

Limitations of Technique

Certain elements lend themselves more readily than others to measurement by neutron activation analysis. These are categorized in Fig. 2 (*6*) according to the approximate sensitivity with which they can be detected. Elements omitted from the figure are those that cannot be detected in quantities of 10 μg or less. The general equation expressing quantitatively the relationship between the amount of stable element in a sample and the activity after irradiation is:

$$N = \frac{A}{\phi\sigma(1 - e^{-\lambda t})} \quad \ldots\ldots (1)$$

in which N is the concentration of stable atoms being bombarded (atoms per cubic centimeter); A, the concentration of activity of induced

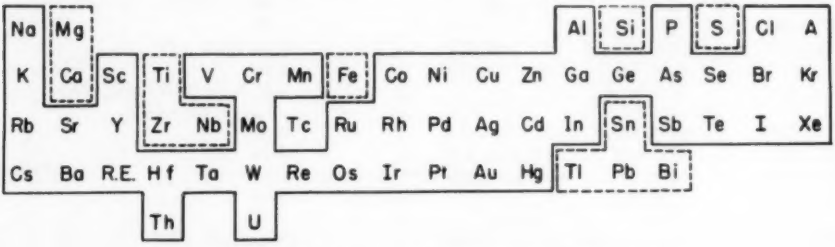
Na Mg Al Si P S Cl A
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba R.E. Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi
Th U

Fig. 2. Limits of Measurement by Neutron Activation

Elements enclosed by solid lines have limits of measurement of 10^{-5}–10^{-1} μg. Those enclosed by dashed lines have limits of measurement of 0.1–10μg. The elements omitted from the figure cannot be detected in quantities of 10 μg or less. A neutron flux of 5×10^{11} neutrons per square centimeter per second and an irradiation period of 10 half-lives or 1 month, whichever was shorter, were assumed.

* In water exposed to a high flux of *fast* neutrons, the principal activity is 7.4-sec N^{16}, arising from the reaction: O^{16} (n,p) N^{16}.

radionuclide (disintegrations per cubic centimeter per second); ϕ, the neutron flux (neutrons per square centimeter per second); σ, the neutron activation cross section of stable isotope (square centimeters per atom); e, the base of the natural system of logarithms (2.7182);

$$\lambda = \frac{0.693}{\text{half-life (seconds)}};$$

and t, the period of irradiation (seconds).

Theoretically, therefore, the concentration of a stable element in water can be calculated once the quantity of radioactivity induced has been established. In actual practice, factors entering such calculations are not always accurately known. For this reason, the equation given serves principally as a guide to the choice of sample size and period of irradiation; quantitative data are usually obtained through simultaneous irradiation of a standard sample with the unknown. Direct comparison of the radioactivities of the standard and the unknown reveals the concentration of the element in question.

Experimental Methods

Drinking waters collected from seven geographical areas in the United States were analyzed. Samples of 30 ml were placed in polyethylene bottles and irradiated in a flux of 6.5×10^{11} neutrons per square centimeter per second.* Based upon theoretical considerations and previous experience, an irradiation period of 16 hr was selected for initial study of the samples.

Radiochemical Procedures

Because the samples contained a variety of constituents, many radionuclides were induced. As a result, gamma spectral studies of liquid samples, as removed from the reactor, were inadequate for identification because of the superposition of spectral peaks. Similarly, decay studies of these samples yielded little useful information. A chemical procedure, therefore, was employed to separate the radionuclides into six groups. Table 2 is a flow sheet of this procedure.

All samples were first aerated in a hood to remove the dissolved radioactive gases (primarily A^{41}). This prevented excessive inhalation of the gases by personnel processing the samples and also prevented colloidal carrydown of radioactive gases during subsequent radiochemical procedures. After aeration, each sample was acidified, and approximately 3 mg of each ion representing the following stable elements was added to the sample: chlorine, bromine, iodine, copper, arsenic, iron, yttrium, cobalt, manganese, zinc, barium, strontium, calcium, sodium, and potassium. These served as isotopic or nonisotopic carriers for the radioactive nuclides present. The resulting mixture was then processed to yield precipitates of silver chloride, bromide, and iodide (*silver group*); copper and arsenic sulfide (*acid sulfide group*); iron and yttrium hydroxide (*hydroxide group*); cobalt, manganese, and zinc sulfide (*basic sulfide group*); calcium, barium, and strontium phosphate (*alkaline-earth group*); and a soluble fraction (*soluble group*).

Complete separation of the various radionuclides in a given sample is not always practical. The use of carriers constitutes the main control. In certain instances, however, specific steps must be employed to control observed contamination. For example, the precipitation of the *hydroxide group* in the

* The samples were irradiated in the Graphite Reactor at Oak Ridge, Tenn.

presence of a high concentration of ammonium chloride was found necessary to prevent excess manganese contamination of this group. Further separation of each chemical group may be done. This was found necessary for the *soluble group*, in which the 1.37-Mev gamma peak of Na^{24} interfered in the gamma spectral identification of K^{42} and Rb^{86} (Table 1). Separation was accomplished by forming the perchlorates and dissolving the sodium perchlorate in a mixture of butyl alcohol and ethyl acetate, in which the potassium and rubidium perchlorates are insoluble (*7*). Although Cu^{64} and As^{76} have gamma spectral peaks of approximately 0.5 Mev, and although both precipitate in the *acid sulfide group*, separation was not necessary because they have widely differing half-lives of 12.8 and 26.4 hr, respectively. Simple decay measurements indicate the radionuclide present, or permit an estimate of relative amounts if both are present.

Because of adverse nuclear, chemical, or physical properties, certain other elements of interest (magnesium, iodine, silica, dissolved gases) required special procedures:

Mg^{27}, which has a 9.5-min half-life, was determined by irradiating a 30-ml sample for 10 min and precipitating the added magnesium carrier and radiomagnesium as $MgNH_4PO_4$. A small amount of Mn^{56} (half-life, 2.6

TABLE 2

Chemical Separation—16-hr Irradiation

1. Add an aliquot of the irradiated sample to a 50-ml centrifuge tube. Aerate to remove radioactive gases. Acidify with HNO_3, and add Cl, Br, I, Cu, As, Fe, Y, Co, Mn, Zn, Ba, Sr, Ca, Na, and K carriers. Precipitate Cl, Br, and I with slight excess of Ag. Heat to coagulate the precipitate. Centrifuge.

2. *Precipitate*: AgCl, AgBr, AgI. Wash with water, filter, mount, and count. Designate as the *silver group*.

3. *Supernate*: Adjust acidity to 0.5*N* HCl. Saturate with H_2S. Centrifuge.

4. *Precipitate*: CuS + As_2S_3. Wash with water, filter, mount, and count. Designate as the *acid sulfide group*.

5. *Supernate*: Transfer to beaker. Add 1 ml. concentrated HCl. Boil until solution is clear. Oxidize Fe^{++} to Fe^{+++} by boiling with HNO_3. Cool solution, and make 1:1 with concentrated HCl. Neutralize with concentrated NH_4OH to precipitate hydroxide. Centrifuge.

6. *Precipitate*: Fe + Y hydroxides. Wash with water, filter, mount, and count. Designate as the *hydroxide group*.

7. *Supernate*: Saturate with H_2S. Centrifuge.

8. *Precipitate*: CoS, MnS, ZnS. Wash with water, filter, mount, and count. Designate as the *basic sulfide group*.

9. *Supernate*: Acidify solution with HCl. Boil to remove H_2S. Add $(NH_4)_2H(PO_4)$ and an excess of NH_4OH. Digest. Centrifuge.

10. *Precipitate*: Ca, Ba, and Sr phosphates. Wash with water containing a few drops of NH_4OH. Filter, mount, and count. Designate as the *alkaline-earth group*.

11. *Supernate*: Na + soluble ions. Transfer aliquot to culture tube for counting. Designate as the *soluble group*.

hr) will coprecipitate with the radiomagnesium, interfering with the 0.83-Mev spectral peak used in the magnesium determination. To avoid such interference, manganese may be removed either as an oxide or as a sulfide (*7*).

For determination of I^{128} (half-life, 25 min), a 30-ml sample was irradiated for 30 min. After oxidation to form iodate and reduction to form free iodine, the added iodine carrier and radioiodine were extracted from the aqueous phase into carbon tetrachloride. Following reduction to iodide and reextraction into a second aqueous phase, the iodine carrier and radioiodine were precipitated as silver iodide (*8*). The gamma radioactivity of the silver iodide precipitate was then measured and the identity of the I^{128} was then confirmed by gamma spectroscopy.

After addition of stable silicon carrier, Si^{31} was separated from the *soluble group* by precipitation as SiO_2 in hot, concentrated H_2SO_4. After the precipitate had been washed in hot water and H_3PO_4, it was dissolved in NaOH and reprecipitated as SiO_2. The Si^{31} radioactivity was then determined from the beta count.

TABLE 3

Chemical Separation—2-Week Irradiation

1. Dissolve irradiated solids in concentrated HNO_3. Heat if necessary. Add P, Cu, Sb, Fe, Co, Ca, and Na carriers. Add molybdic acid reagent, and boil to coagulate the precipitate. Centrifuge.

2. *Precipitate*: H_3PMo_{12}. Wash in dilute HNO_3, dissolve in NH_4OH. Acidify with HCl, and add citric acid. Cool, add magnesia mixture and NH_4OH in excess. Cool, filter, mount, and beta count. Designate as the *phosphorus group*.

3. *Supernate*: Neutralize with NH_4OH, and adjust to 0.3*M* HCl. Saturate with H_2S, and centrifuge.

4. *Precipitate*: $CuS + Sb_2S_5$. Wash with hot water, filter, mount, and gamma count. Designate as the *antimony group*.

5. *Supernate*: Boil, and add HNO_3 and $Br_2 \cdot H_2O$ until solution is clear. Add NH_4OH. Centrifuge.

6. *Precipitate*: $Fe(OH)_3$. Discard.

7. *Supernate*: Saturate with H_2S. Centrifuge.

8. *Precipitate*: CoS. Discard.

9. *Supernate*: Add HCl and $Br_2 \cdot H_2O$, and boil until solution is clear. Add saturated $(NH_4)_2C_2O_4$, heat, and make basic with NH_4OH. Centrifuge.

10. *Precipitate*: CaC_2O_4. Wash with water, filter, mount, and beta count. Designate as the *calcium group*.

11. *Supernate*: Discard.

Separation of the dissolved gases in the irradiated samples was performed by heating the water to 50°C for about 15 min. The gases were collected in a 250-ml evacuated flask and the radionuclides identified by gamma scintillation spectroscopy.

Certain other elements of interest—phosphorus, antimony, and calcium—have half-lives too long for determina-

tion with only 16-hr irradiation. For these analyses, samples were evaporated to dryness, irradiated for 2 weeks, allowed to stand to bring about decay of short-lived radionuclides, and then separated for radioactive assay according to the chemical scheme outlined in Table 3. The reagents, such as molybdic acid and magnesia mixture, used in this scheme were similar in composition to those reported by Lundell and Hoffman (*7*).

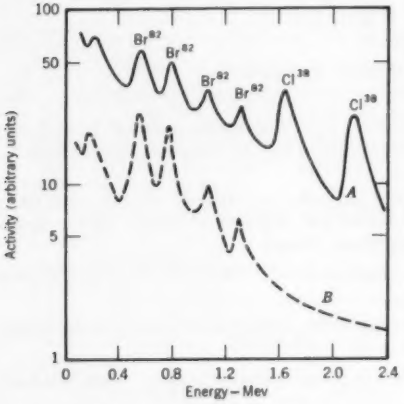

Fig. 3. Silver Group

Gamma spectral data for Curves A *and* B *were obtained 3 hr and 24.7 hr, respectively, after the end of the 16-hr irradiation period. The major radionuclides of the silver group are:* Br^{82} *(half-life, 35.9 hr), characterized by the energy peaks at 0.55, 0.78, 1.04, and 1.32 Mev; and* Cl^{38} *(half-life, 37.3 min), characterized by the energy peaks at 1.60 and 2.15 Mev.*

Radioactivity Procedures

Each chemical group was subjected to studies of gross beta or gamma decay, beta absorption determinations, and gamma spectral analyses. An interpretation of these data, together with the knowledge of the chemistry of the particular group, served to identify the radionuclides in the sample.

Gamma spectral data for the six chemical groups separated from irradiated Chicago drinking water are shown in Fig. 3–8. Data for the *silver group* (Fig. 3) were obtained 3 hr and 24.7 hr after the end of the 16-hr irradiation period. The major radionuclides in this group are 35.9-hr Br^{82} and 37.3-min Cl^{38}. The Cl^{38} is characterized by the rapidly decaying 1.60- and 2.15-Mev peaks, and the Br^{82} by the longer-lived lower energy peaks at 0.55, 0.78, 1.04, and 1.32 Mev.

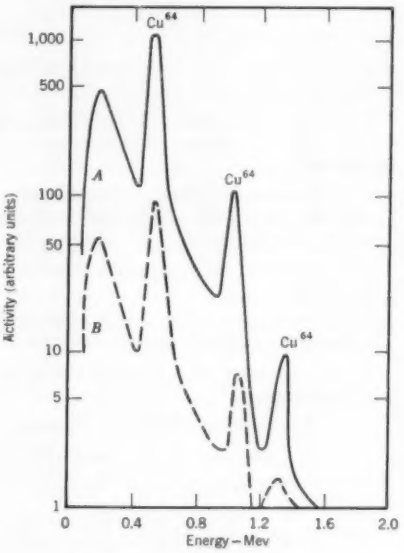

Fig. 4. Acid Sulfide Group

Gamma spectral data for Curves A *and* B *were obtained 4.5 hr and 25.3 hr, respectively, after the end of the irradiation period. The radionuclide* Cu^{64} *(half-life, 12.8 hr) was characterized by energy peaks at 0.51, 1.02, and 1.34 Mev.*

Spectral data for the *acid sulfide group* are shown in Fig. 4. These data

are typical of the induced radionuclide Cu^{64} and indicate the presence of stable copper in the sample. In the *hydroxide group*, fluorine is carried down as a complexed ion with iron. Data for this group (Fig. 5) show the occurrence of radioactive F^{18}. This nuclide does not indicate the presence of stable fluorine in the water. The probable origin of F^{18} is through a proton-induced reaction with O^{18}, the energetic protons arising from fast neutron collisions with hydrogen nuclei in the water (*9*). If stable fluorine (F^{19}) were present in the sample, thermal-neutron irradiation would have produced F^{20}. This nuclide has a half-life of 10.7 sec; therefore, it would not have been detected under the conditions of this study. The presence of manganese (Mn^{56}) in this same group is the result of coprecipitation. Radioactive iron was not detected, even though stable iron may have been present, because the half-lives of its radioisotopes are long when compared to the irradiation time selected for this study.

Data for the *basic sulfide group* are shown in Fig. 6. Two radionuclides, Zn^{69m} and Mn^{56}, were identified in this fraction. The former was indicated by the long-lived 0.44-Mev peak, the latter by the short-lived 0.85-Mev peak. Data for the *alkaline-earth group* (Fig. 7) indicate Ba^{139} and Sr^{87m}. Similarly, Na^{24}, K^{42}, and Rb^{86} were identified on the basis of data for the *soluble group* (Fig. 8).

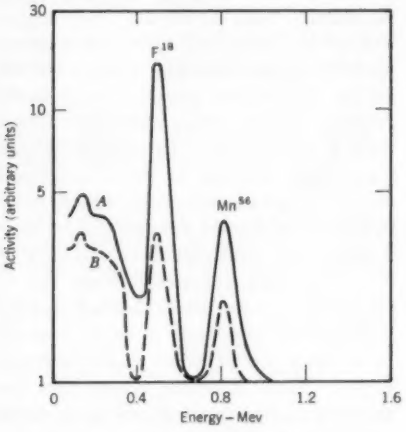

Fig. 5. Hydroxide Group

Data for Curves A *and* B *were obtained 3.2 hr and 8.1 hr, respectively, after the end of the irradiation period. The radionuclides identified are: F^{18} (half-life, 1.87 hr), characterized by an energy peak at 0.51 Mev; and Mn^{56} (half life, 2.6 hr), characterized by an energy peak at 0.85 Mev.*

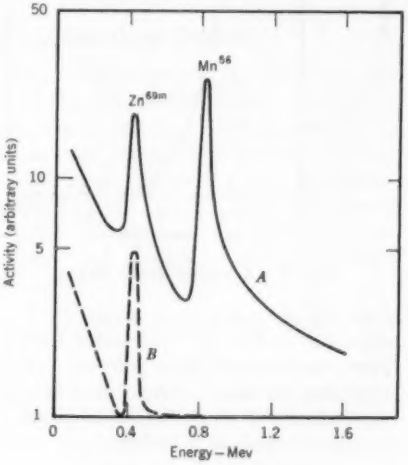

Fig. 6. Basic Sulfide Group

Data for Curves A *and* B *were obtained 3.75 hr and 27.2 hr, respectively, after the end of the irradiation period. The radionuclides identified are: Zn^{69m} (half-life, 13.8 hr), energy peak at 0.44 Mev; and Mn^{56} (half-life, 2.6 hr), energy peak at 0.85 Mev.*

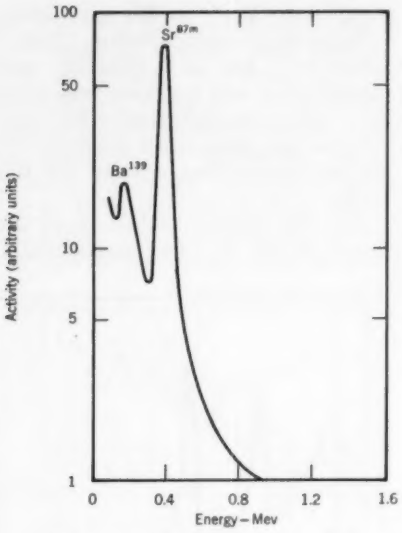

Fig. 7. Alkaline-Earth Group

Data for the curve were obtained 2.5 hr after the end of the irradiation period. The radionuclides identified are: Ba^{139} (half-life, 84 min), energy peak at 0.16 Mev; and Sr^{87m} (half-life, 2.8 hr), energy peak at 0.39 Mev.

A^{41} was the only dissolved gas detected; its spectral curve is shown in Fig. 9. Data for the chemically separated magnesium and iodine fractions are shown in Fig. 10 and 11; Mg^{27} and I^{128} were present in these fractions.

After the various elements in a chemical group had been identified, quantitative data were obtained by direct comparison of the areas under a given spectral peak for sample and standard. Such areas are representative of the counting rates for gamma photons of the particular energy shown by the plot of the peak in the figures. In these studies, areas were determined with a planimeter. Proper allowance was made for the contribution from scattered gamma photons, which were originally of higher energies (*4*). For comparison, concentrations of stable elements were calculated from Eq 1. In general, data so calculated agreed within ±30 per cent of data obtained by comparison of areas under spectral peaks. Thus, it would appear that the theoretical approach provides a rapid semiquantitative technique.

TABLE 4

Neutron Activation Analysis of Drinking Water

Element*	Concentration—*mg/l*						
	Atlanta, Ga.	Charlottesville, Va.	Chicago, Ill.†	Cincinnati, Ohio	Denver, Colo.	New York, N.Y.	Oak Ridge, Tenn.
Br	0.17	0.05	0.32	0.12	0.18	0.07	0.18
Cl	12.0	12.1	6.6 (7.0)	5.1	20.8	6.7	3.1
Cu	0.003	0.007	0.004 (0.004)	0.010	0.017	0.005	0.003
As	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Mn	0.0028	0.040	0.0004	0.0028	0.0098	0.0049	0.0014
Zn	<0.01	0.038	0.028 (0.023)	<0.01	<0.01	0.047	<0.01
Ba	0.005	<0.005	0.010	<0.005	<0.005	0.006	0.021
Sr	0.14	0.08	0.29 (0.48)	0.61	1.23	0.10	0.38
Na	3.8	4.0	6.5 (4.40)	1.6	21.2	1.6	6.4
Rb	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2
K	0.72	0.53	1.9 (2.50)	3.6	2.1	0.67	1.4
Mg	1.1	8.5	20.7 (9.50)	3.6	4.5	5.0	2.8
I	0.027	0.018	0.027	0.027	0.007	0.004	0.002
Si (SiO_2)	6.6	1.7	1.85 (2.1)	4.25	4.2	3.8	1.70
P	0.0017	0.014	0.0037 (0.0013)	0.029	0.011	0.0031	0.005
Sb	0.057	0.044	0.03	0.016	0.023	0.04	0.03
Ca	11.6	12.3	34.6 (40.2)	63.3	23.5	8.5	36.0
Th	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.02

* Argon was identified but not measured.
† Values in parentheses represent data obtained by conventional methods.

For pure beta emitters, quantitative data were obtained by comparing beta counting rates for chemical fractions from unknowns and similarly irradiated standards. Chemical yields of unknowns were estimated by weighing separated fractions, to which a known weight of stable carrier had been added.

Experimental Results

The drinking waters studied came from the following cities and sources of supply:

Atlanta, Ga.	Chattahoochee River
Charlottesville, Va.	Moorman's River (Ragged Mountain Watershed)
Chicago, Ill.	Lake Michigan
Cincinnati, Ohio	Ohio River
Denver, Colo.	South Platte River (Blue River)
New York, N.Y.	Catskill Reservoir and Upper Delaware Basin
Oak Ridge, Tenn.	Clinch River

Analytical results are summarized in Table 4.

TABLE 5

Neutron Activation Analysis of Demineralized Water

Element	Induced Radionuclides	Concentration *mg/l*
Br	Br^{80m}	0.01
	Br^{82}	0.01
Cu	Cu^{64}	0.0001
Mn	Mn^{56}	0.0005
Na	Na^{24}	0.01

Supplementary Studies

As demonstrated by the data in Table 4, neutron activation analysis is extremely sensitive and is applicable to a wide range of elements. To exploit these features, two additional studies were made: one on water passed through an ion-exchange column, and another on short-lived nuclides.

Analysis of Demineralized Water

The results of the study on water passed through a mixed-bed ion-exchange column are shown in Table 5. Only those stable elements determined

TABLE 6

Sensitivity of Analytical Methods

Element	Limit of Detection—μg						
	Activation Analysis		Emission Spectroscopy		Flame Photometry	Colorimetric	Amperometric Titration
	5×10^{11} Flux	1×10^{13} Flux	Copper Spark	Graphite			
Mg	0.6	0.03	0.01	0.1	1.0	0.06	
Cl	0.03	0.0015				0.04	0.1
Cr	0.2	0.01	0.05	2.0	1.0	0.02	1.0
Mn	0.0006	0.00003	0.02	0.2	0.1	0.001	0.0003
Fe	9.0	0.45	0.5	0.2	2.0	0.05	2.0
Cu	0.007	0.00035		0.2	0.1	0.03	10.0
Zn	0.04	0.002	2.0	20.0	2,000.0	0.016	10.0
As	0.002	0.0001	5.0	10.0		0.1	0.4
Se	0.05	0.0025				5*	200.0

* Datum from the Analytical Reference Service, Robert A. Taft Sanitary Engineering Center, Cincinnati.

by the application of the general chemical scheme outlined in Table 2 are reported. Each determination, although representing only an extremely small amount of stable element, was based on a counting rate of the order of thousands per minute.

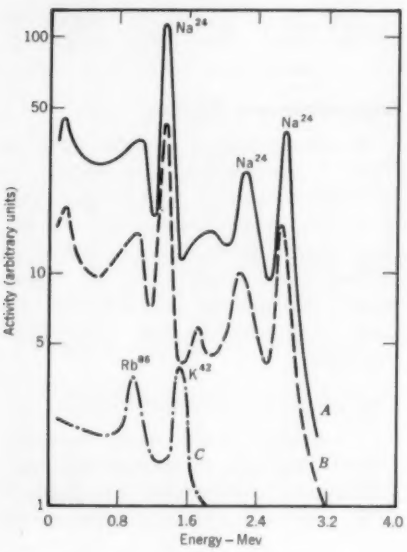

Fig. 8. Soluble Group

Data for Curves A *and* B *were obtained 4 hr and 24.5 hr, respectively, after the end of the irradiation period. Curve* C *was obtained from K and Rb separated from the soluble group. The radionuclides identified are: Na^{24} (half-life, 15 hr), energy peaks at 1.37 and 2.75 Mev; K^{42} (half-life, 12.5 hr), energy peak at 1.53 Mev; and Rb^{86} (half-life, 18.7 days), energy peak at 1.08 Mev.*

Several of the newer reactors have fluxes 10–20 times that available in the Oak Ridge Graphite Reactor. The sensitivity for elements irradiated in these reactors will be increased proportionately. Table 6 lists the sensitivity for selected elements in water for

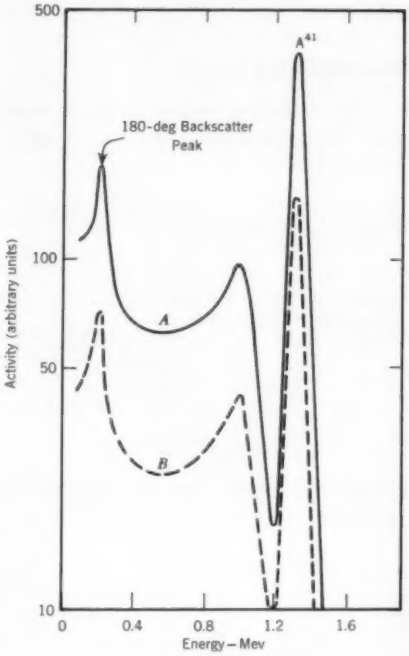

Fig. 9. Dissolved Gases

Data for Curves A *and* B *were obtained 1.8 hr and 3.7 hr, respectively, after the end of the irradiation period. The only dissolved gas detected, A^{41} (half-life, 1.8 hr), was characterized by an energy peak at 1.29 Mev.*

As may be concluded from the discussion presented earlier, the sensitivity of activation analysis for a given element depends upon a number of factors, prominent among which are reactor flux and period of irradiation. fluxes of 5×10^{11} and 10^{13} neutrons per square centimeter per second. Irradiation is assumed to have continued for 10 half-lives of the induced radionuclide or for 30 days, whichever is shorter. Also presented for compari-

son are sensitivities of other common methods of analysis (*10*).

Analysis of Short-Lived Nuclides

Because of the time required for chemical processing of irradiated samples, stable elements yielding very short-lived radionuclides are not readily detected in a study of this type. Inasmuch as there are a number of elements of interest in this category, the feasibility of more rapid approaches was investigated. The element chosen for study was aluminum, for which conventional analytical methods are unsatisfactory. Stable aluminum, under neutron bombardment, yields the radioactive isotope Al^{28}, which decays with a half-life of 2.3 min. Because of the need for speed, irradiated samples were spectrally analyzed in liquid form. Chemical procedures were limited to a precipitation of interfering chlorine activity only where necessary. Comparison of a series of standards and unknowns,* after an irradiation period of 5 min, showed that an accuracy within ±5 per cent was easily obtainable in the concentration range of 0–2 ppm.

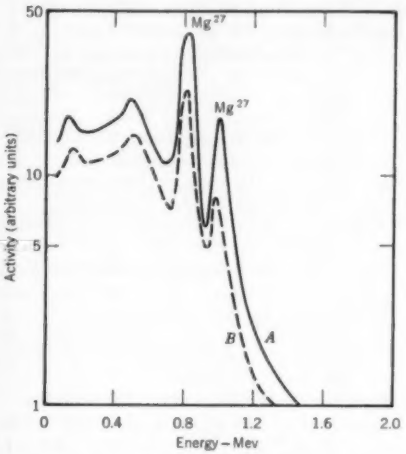

Fig. 10. Magnesium Separation

Data for Curves A *and* B *were obtained 29 min and 40 min, respectively, after the end of the irradiation period. Mg^{27} (half-life, 9.5 min) was characterized by energy peaks at 0.83 and 1.02 Mev.*

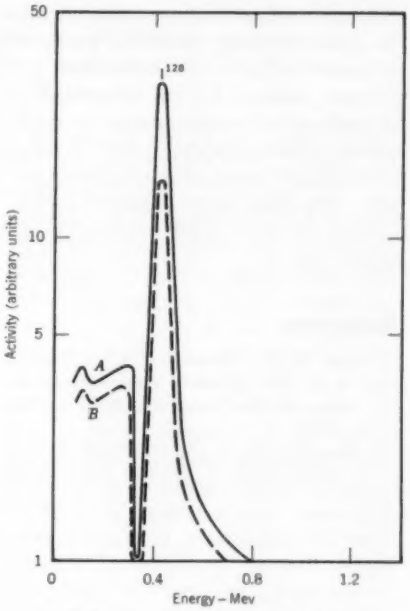

Fig. 11. Iodine Separation

Data for Curves A *and* B *were obtained 40 min and 58 min, respectively, after the end of the irradiation period. The identified radionuclide I^{128} (half-life, 25 min) had an energy peak of 0.46 Mev.*

Conclusion

Neutron activation analysis has potentialities as a valuable new tool for

* Made by the Analytical Reference Service, Training Program, Robert A. Taft Sanitary Engineering Center, Cincinnati.

the determination of certain elements in water. The method is specific in that each induced radionuclide decays with its own characteristic radiation and half-life. It is also extremely sensitive, and for qualitative or semiquantitative data, it is simple and rapid.

With the increasing accessibility of reactors, the activation technique can be used by many qualified personnel of water utilities. Radiochemical procedures, utilized for the determination of radioactive contaminants in water, are equally applicable here. Because of its many outstanding features, neutron activation analysis should be considered by personnel responsible for water analysis.

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Insecticide Pollution of Water Resources

H. Page Nicholson

A paper presented on Apr. 6, 1959, at the Southeastern Section Meeting, Columbia, S.C., by H. Page Nicholson, Sr. Scientist in Charge, Insecticide Pollution Investigations, San. Eng. Services, USPHS, Atlanta, Ga.

THE question of whether insecticides damage water resources is offered as a subject for thought; the answer has not yet been resolved fully. The term "water resources" as used in this article means not only water itself but also the useful life existing in it, such as fish and organisms upon which fish depend directly or indirectly for food.

Insecticides are employed in many ways and situations, but the people occupied with the control of water supply and water pollution are most concerned with large-scale applications that might result in damage to water resources. The principal large-scale uses are in agriculture, although considerable quantities are used to control forest and biting pests.

The use of insecticides in agriculture is routine and is necessary for profitable production of many food and fiber crops. Prior to 1940, the chemical defense against insect pests consisted mainly of toxicants of mineral origin. A few organic insecticides were on hand, but these had comparatively limited use, except for a few vegetable extracts that quickly lost toxicity or volatilized after application. Damage to water resources from insecticides prior to 1940 appears to have been negligible.

The period since 1940, at the beginning of which DDT (dichloro-diphenyl-trichloroethane) came into use, has been one of intensive research resulting in many new synthetic organic insecticides. By 1955, more than 100 such compounds were in commercial use (*1*), but only fifteen to eighteen account for the majority of sales (*2*).

Farmers have received the new organics with enthusiasm because of their greater efficiency in protecting crops. Some of these compounds are characterized by long residual activity, effectiveness against a wide variety of insect pests, and amenability to mass dispersal by means of ground or air equipment. Others are advantageous because of their transient nature, ability to kill insects quickly, or low toxicity to man and livestock. With some notable exceptions, development has taken place along two chemical lines: the organic phosphorus compounds, the first of which became available in 1948, and the chlorinated hydrocarbons.

The organic phosphorus compounds include insecticides that hydrolyze with comparative rapidity. One of the longer lasting ones in common use, parathion, is 50 per cent hydrolized in water in 120 days (*1*). Others have a duration measured in hours or a few days. In general, the organic phos-

phorus insecticides are less toxic to fish than are the chlorinated hydrocarbons (*3*). For these reasons, those currently in use are not as apt to damage water resources as are the chlorinated hydrocarbons, unless they are applied directly to water.

The chlorinated hydrocarbon insecticides constitute the most important group at this time. Eight of these compounds—aldrin, BHC (benzene hexachloride), DDT, dieldrin, endrin, heptachlor, toxaphene, and TDE (tetrachlorodiphenylethane)—are the insecticides that have the greatest potential for damaging water resources. All are compounds used extensively to control field and forest insects; they have long residual activity and low solubility in water.

Extent of Usage

In order to gain background material useful for evaluating damage to water resources, efforts have been made to learn the extent of insecticide usage in the agriculture of the Southeast. It is desirable to know not only how much insecticide is being used, but also what kinds are used and where they are applied. Information concerning the quantity sold annually has proved difficult to obtain on a regional basis. Manufacturers are understandably reluctant to release data revealing the volume of sales at their various outlets. Several state agricultural extension services in the Southeast have obtained annual estimates through county agricultural agents, but this practice was discontinued several years ago, except in Alabama. Consequently, it has been necessary to depend largely upon data gathered between 1950 and 1955, and upon other more up-to-date related information, to piece together some idea of the extent that insecticides are used in agriculture.

The market for insecticides in Mississippi, Alabama, Georgia, South Carolina, Florida, and Tennessee was served during the period 1957–58 by 223 * local agricultural insecticide–formulating companies. No monetary value could be placed on products sold by these companies, but the Florida State Plant Board estimates that in 1957 the cost to the consumer for insecticides alone to control Florida's most destructive insects approached $41,000,000 (*4*).

In 1957, approximately 7,500,000 acres in the Southeast were planted in leading commercial crops that require some degree of protection by insecticides.† These crops were cotton, peanuts, soybeans, tobacco, truck crops, and tree fruits (including nuts and grapes). This figure varies somewhat from year to year, depending upon the demand for the products and the acreage restrictions established by the US Department of Agriculture. Profitable commercial production of these crops depends on protection against damage by insects; therefore, it is safe to assume that most of this vast acreage was protected by insecticide to some degree. Cotton accounted for nearly half this acreage in 1957 and is the leading commercial crop in number of acres in each state of the region, except Florida.

Commonly Used Insecticides

Data on insecticide usage have been acquired from Alabama, Mississippi,

* From lists of registrants on file with state departments of agriculture.

† Data from Agricultural Marketing Service, US Department of Agriculture, Atlanta, Ga.

and South Carolina (*5*). The quantities used vary from year to year according to the acres planted, the abundance of insects and the severity of their depredations, the species involved, weather conditions, and the kinds of insecticides currently popular. These data show that a greater quantity of DDT is used in the Southeast than is any other insecticide. DDT is used widely for the control of insect pests that damage cotton, peanuts, soybeans, and truck crops. Toxaphene and benzene hexachloride hold second and third place, respectively, in terms of pounds of technical grade insecticide applied.

Application to Cotton

Most detailed data are available regarding the insecticides used on cotton. The average amount of technical grade insecticide applied to cotton varies from 3 to 7 lb/acre annually and consists chiefly of chlorinated hydrocarbon compounds (*5*). On the basis of these annual averages and the total cotton acreage of 3,633,400 harvested in 1957, 11,000,000–25,000,000 lb of technical grade insecticide were applied to cotton in the six southeastern states that year. It has been said that during the past 10 years, 60 per cent of the total cultivated acreage in the 13 delta counties of Mississippi, the chief cotton-growing section of that state, has had about 70–100 lb/acre of technical grade insecticide deposited on it (*6*).

Toxicity

What becomes of this vast amount of toxic material after it has been applied to our soil? Part of it is mixed into the soil where it remains indefinitely. Some of it deteriorates, but surprisingly little is known about the loss of stable chlorinated hydrocarbon insecticides from the soil. It is suspected that much of it is washed into the nearest watercourse from the soil surface. Reason dictates that insecticides cannot be deposited on uplands year after year without eventually getting into lakes and rivers.

What evidence is there that insecticides have entered bodies of water or have damaged water resources? Several instances are on record from various places in the United States where insecticides, being employed to control forest or agricultural pests, accidentally have been released over streams and have resulted in severe damage to aquatic life. Sometimes these applications are made purposely, with damaging side effects. In 1955, such an incident occurred in St. Lucie County, Fla., where 2,000 acres of salt marsh were treated with dieldrin at the rate of 1 lb/acre for the control of sandfly larvae, the adults of which are biting pests (*7*). The fish in the canals bisecting the marsh that were killed as a result of this treatment were estimated to weigh a total of 20–30 tons, and repopulation did not begin for at least 4 weeks. Aquatic crabs and other crustaceans apparently suffered near annihilation.

There is evidence, too, that insecticides washed from the soil by rains have entered surface waters and caused damage. In 1950, fish were decimated in fifteen streams tributary to the Tennessee River in Alabama by toxaphene and other insecticides applied to cotton fields (*8*). Two of these streams were sources of municipal water supply, but there was no evidence of adverse effects on humans. The daily deaths of goldfish, suspended in cages in the river at one of these water intakes,

showed that passage of the toxic water required at least a week.

DDT

Mass killings of fish readily come to the attention of the public, but there may be more insidious damage. In 1953, scientists at the Robert A. Taft Sanitary Engineering Center in Cincinnati recovered DDT from the Detroit River and Lake St. Clair in both the raw and treated water (9). DDT was present in the initial sample taken in January and persisted in samples collected over a 6-month period. It was recovered also from waters of the Mississippi River at Quincy, Ill., and at New Orleans; the Missouri River at Kansas City, Kan.; and the Columbia River at Bonneville Dam, located between Washington and Oregon, during the months of April, May, and June 1957. It was presumed that large-scale insect control operations were the source of the DDT, which was estimated to have been present in amounts varying from 0.001 to 0.02 ppm.

There is no record that aquatic life suffered from the presence of this DDT, although it is doubtful that an investigation was made. It can only be speculated that losses may have occurred. These losses need not have been to fish directly, but to their food supply. Therefore, the effects on aquatic organisms of the minute amounts of insecticides that trickle into rivers and lakes may be no less catastrophic in the long run than the sudden appearance of lethal quantities of these compounds. This possibility remains to be more fully evaluated.

It has been mentioned that DDT was recovered from treated municipal water. The quantity present was too small to affect humans adversely and, in fact, constituted a minor proportion of the exposure to DDT normally encountered by a large part of the population (*10*). This contention is further supported by the work of Ortelee, who found no evidence of chronic poisoning in men who were exposed to DDT for as long as 6.5 years, in such a way that they absorbed an average of about 200 times as much DDT as that absorbed by the general population from their food (*11*).

Other Insecticides

A full evaluation of the effects of other currently used insecticides on the quality of water for human consumption remains to be made. Generally speaking, it may be concluded that if insecticides are not present in a stream or lake in sufficient quantities to kill fish, there will be no known significant public health hazard due to insecticides in drinking water from these sources. Benzene hexachloride, however, can impart a disagreeable taste to water at 0.02 ppm (*12*).

Detection and Removal

There are no chemical tests that a water plant operator can perform quickly and routinely to detect the presence of organic insecticides. He can, however, employ a simple, continuous bioassay procedure to detect the presence of insecticides or other toxic substances within the range lethal to fish. This can be done by maintaining a pool, either indoors or out, stocked with goldfish or some other suitable variety. Treated water taken from the system just prior to postfiltration disinfection should be allowed to flow through this pool continuously. If it is necessary to use water after postfiltration disinfection, care should be taken to aerate the influent water

to permit the escape of chlorine or chlorine compounds, which, when dissolved in water, will kill fish.

Studies of rotenone and toxaphene formulations by Cohen and colleagues (*13*) at the sanitary engineering center, indicate that these insecticides may be removed from water during the treatment process by use of activated carbon in amounts depending upon the toxicant present and its concentration. The fish pool bioassay would be an indication to the plant operator when his rate of carbon application was sufficient to effect removal. Fish suspended in cages in the raw-water supply would also indicate when the passage of toxicity had ceased.

Current Investigations

The Water and Pollution Control Office of USPHS in Atlanta, Ga., in cooperation with the state health departments of Alabama, Florida, Georgia, Mississippi, South Carolina, and Tennessee, has undertaken a program of field research to evaluate the insecticide pollution problem. Related work also is being done at the sanitary engineering center in Cincinnati. These studies seek to determine:

1. The identity and concentration of insecticides present in surface and ground waters
2. The factors that contribute toward their presence there
3. Their effects on fish and other forms of aquatic life
4. The extent to which insecticides are present in treated water for domestic use.

It is postulated that insecticide pollution may be correlated with soil type, topography, and rainfall. If these relationships can be discovered, it may be possible to predict conditions under which insecticides may damage water resources. These criteria would prove most useful in preventing water pollution by insecticides, and in planning future large-scale insect control campaigns.

Summary

Since 1940, synthetic organic insecticides have come into general use. It is estimated that in 1957, 11,000,000–25,000,000 lb of these compounds (technical grade) were applied to cotton in six southeastern states. Total insecticide usage in these states is unknown, but cotton accounted for nearly half the acreage planted in 1957 in leading commercial crops requiring protection by insecticides.

It is suspected that a substantial quantity of the stable, chlorinated hydrocarbon insecticides applied to farm crops wash from the soil surface into streams and lakes, where serious damage may result to water resources, particularly to fish and other aquatic life. The effects of DDT on humans have been evaluated thoroughly, but a more complete evaluation of the effects of other currently used insecticides on water quality for human consumption remains to be made. Generally speaking, however, it may be concluded that if insecticides are not present in a stream or lake in sufficient quantities to kill fish, there will be no known significant public health hazard due to insecticides in drinking water from these sources.

A simple, continuous bioassay procedure has been proposed that may be employed routinely by municipal water plant operators to detect in finished water the presence of insecticides or other toxic substances within limits lethal to fish.

The ultimate objectives of the USPHS program to evaluate the insecticide pollution problem are listed.

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Pollution Control on the Illinois Waterway

E. Hurwitz and George R. Barnett

A contribution to the Journal by E. Hurwitz, Director of Labs., and George R. Barnett, Sr. Chemist, both of the Metropolitan Sanitary District of Greater Chicago, Chicago, Ill.

THE natural watershed of the Illinois River is approximately 100 mi wide and 260 mi long and stretches diagonally across the northern half of the state in a southwesterly direction from Lake Michigan (Fig. 1). It drains approximately 28,127 sq mi. The watershed has been artificially increased by the construction of the Chicago Sanitary and Ship Canal, which cuts through the low divide between the DesPlaines River, a tributary of the Illinois, and the Chicago River, which originally discharged into Lake Michigan. The canal reversed the flow of the Chicago River, causing it to flow into the DesPlaines River and adding about 217 sq mi to the watershed of the Illinois River system.

The city of Chicago lies at the mouth of the Chicago River along the southwestern shore of Lake Michigan. Ever since 1840, when Chicago had a population of only 4,470, Lake Michigan has been the source of water supply for the community. From the time the first sewers were built in 1856 to the time of the construction of the canal, the lake was also the point of discharge, either directly or indirectly through the Chicago River, of most of the sewage of the community.

Early Sanitary Conditions

As the city grew, drainage and health conditions deteriorated, until by 1885 the pollution of the Chicago River menaced the health of the entire population. The unsanitary condition of the water supply was a topic of national ill-repute, rivaling in notoriety the Thames in England and the sad condition of many of the streams in Europe that led to Coleridge's musings about the Rhine in his "Ode to the Rhine," which is quoted in part below:

In Cologne, a town of monks and homes
And pavements fanged with murderous stones
And rags and tags and hideous wenches,
I counted four and twenty stenches
All well-defined, and several stinks,
Ye nymphs that reign o'er sewers and sinks,
The River Rhine, it is well known,
Doth wash your city of Cologne.
But tell me, nymphs, what power divine
Shall henceforth wash the River Rhine?

During periods of storm flow, large quantities of decomposed sludge solids were washed from the bed of the Chicago River into the lake, at times reaching the intake crib at Chicago Ave. Attempts were made to alleviate pollution of the water supply by using the Illinois-Michigan Canal, completed in 1848, as a partial outlet for Chicago sewage. Later, in 1861, sewage diluted by lake water was pumped into the canal by the city from the southern branch of the Chicago River at Bridgeport with little effect on the

pollution of the river and lake even at a pumpage of 600–800 cfs.

Creation of MSDGC

In 1886 the Chicago City Council established a drainage and water supply commission to solve the water supply, drainage, and sewage problems of the community. After intensive study, the commission recommended that sewage be diverted from Lake Michigan by construction of a canal across the divide separating the drainage areas of the Chicago and Illinois rivers. The canal was to be excavated at such a gradient that the flow of the Chicago River would be reversed and was to provide sufficient capacity to permit a flow of 3.33 cfs per 1,000 population, which at that time was considered the minimum dilution necessary to avoid a pollution nuisance in the stream. Based on a future population of 3,000,000, the canal would have a capacity of 10,000 cfs between the South Branch of the Chicago and DesPlaines rivers.

To carry out the project recommended by the drainage commission, the state legislature created the Metropolitan Sanitary District of Greater Chicago (MSDGC) in 1889 for the purpose of: "providing for the disposal of sewage of the district by dilution and outlet into the Illinois River and to provide such other sewage disposal as shall preclude the contamination of Lake Michigan water supply." The territory embraced by the MSDGC included the city of Chicago and a large contiguous area.

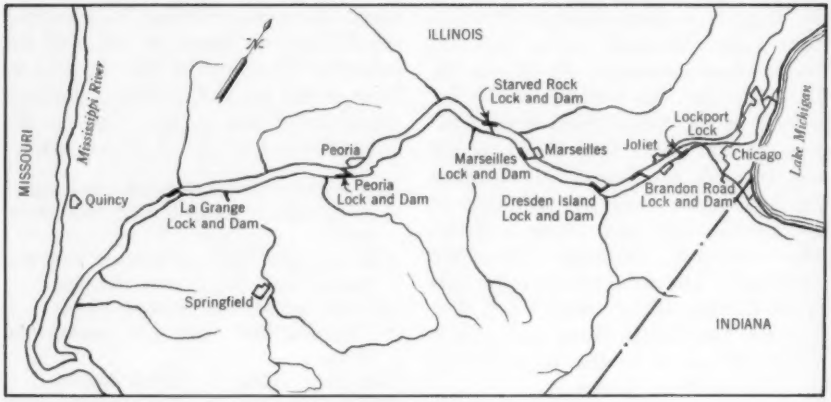

Fig. 1. Illinois Waterway System

Most of the points discussed in the text are shown above.

Dilution Project

The Chicago Sanitary and Ship Canal was constructed and put into operation in January 1900. The Main Channel extends southwest from Damen Ave., a distance of 30 mi, to Lockport. It enters the DesPlaines River watershed at Summit, 7.8 mi from its source, and parallels the DesPlaines River for 25 mi, finally emptying into the river 1 mi beyond Lockport.

Supplementary works have been undertaken to use the artificial drainage area to the fullest advantage. Sections of the South Branch, the Main Channel, and North Branch have been widened. The North Shore Channel, extending from Lake Michigan in Wilmette to the North Branch of the Chicago River, was started in 1908 and completed in 1910. The Calumet-Sag Channel, started in 1911 and completed in 1922, extended west from the Little Calumet River at Blue Island to the Main Channel at Sag. In addition to these main drainage channels, pumping stations and intercepting sewers were built and improvements in the sewerage system were made in order to conduct the sewage of the district to the main drainage canal.

The net effect of the dilution projects was to remove from Lake Michigan practically all of the sewage on the Cook County lake front and to prevent any further discharge of sewage into the lake. At the same time the discharge from the canal greatly increased the flow along the whole length of the Illinois system and polluted the stream with sewage and industrial wastes from Chicago.

Early Industrial-Waste Studies

By 1909 the growth of Chicago and its industries (Table 1) had so increased pollution of the waterway that it became evident that the dilution project would have to be supplemented by other means. The MSDGC began an intensified study of sewage treatment. Testing stations were installed to study the strength and character of the sewage of the city and the major industrial wastes—stockyard, packinghouse, tannery, and corn product wastes—and methods of treating them.

Diversion Program

The original diversion from Lake Michigan began with the opening of the Illinois-Michigan Canal in 1848. The first diversion was for navigation, but as the pollution of the river became more and more offensive the city began to pump water to the canal. By lowering the summit in 1871 and by installing larger pumps in 1885, provision was made to discharge 1,000 cfs, but because of the low lake levels only 600–800 cfs was available.

TABLE 1

Population and Area of Sanitary District of Chicago

Year	Population	Industrial*	Area *sq mi*
1890	1,070,000		185.00
1900	1,638.656		185.00
1910	2,308,276		385.10
1920	2,986,000		395.51
1930	3,901,569		442.35
1940	3,962,514		442.85
1950	4,316,590	3,005,100	470.00
1957	4,800,000†	3,871,950	920.14

* Based on 0.167 lb 5-day BOD exclusive of the human population.
† Estimated.

The main drainage channel was opened in 1900 with a flow limited to 5,000 cfs. This was modified from time to time by the Secretary of War and by edict from the US Supreme Court, until, in 1939, the allowable diversion was cut to 1,500 cfs. Table 2 shows the diversions from the lake to date (1959).

Missouri Objections

The first opposition to diversion of water from Lake Michigan through the main drainage channel came from Missouri on behalf of the city of St. Louis. In 1900 Missouri asked the courts to

TABLE 2

Diversions From Lake Michigan, 1900–58

Period of Record*	Total Flow at Lockport *cfs*	Domestic Pumpage *cfs*	Inflow, Infiltration, and Runoff *cfs*	Diversion *cfs*
1900–04	4,220	547		3,673
1905–09	5,401	697		4,707
1910–14	7,264	857		6,407
1915–19	8,417	1,006		7,411
1920–24	8,620	1,217		7,403
1925–29	8,894	1,488	27	7,379
1930–34	8,154	1,682	9	6,462
1935	8,093	1,602	7	6,484
1936	6,607	1,712	33	4,862
1937	6,677	1,665	23	4,989
1938	6,648	1,604	45	4,999
1935–38	7,016	1,646	27	5,334
1939	3,132	1,586	47	1,499
1940	3,319	1,589	49	1,681
1941	3,341	1,610	235	1,496
1942	3,269	1,575	166	1,528
1943	3,472	1,605	367	1,500
1944	3,412	1,606	275	1,531
1939–44	3,324	1,595	189	1,539
1945	3,402	1,587	317	1,498
1946	3,373	1,600	278	1,495
1947	3,435	1,616	319	1,500
1948	3,496	1,640	356	1,500
1949	3,323	1,641	189	1,493
1945–49	3,406	1,617	292	1,497
1950	3,472	1,607	366	1,499
1951	3,568	1,616	462	1,490
1952	3,551	1,633	421	1,497
1953	3,338	1,692	147	1,499
1954	3,519	1,708	314	1,497
1950–54	3,489	1,651	342	1,496
1955	3,478	1,739	239	1,500
1956†	3,710	1,805	206	1,699
1957‡	4,387	1,784	216	2,387
1958	3,464	1,760	206	1,498
1955–58	3,759	1,772	217	1,771

* Where ranges are given, data represent annual averages.
† Increased by order of Supreme Court.
‡ Increase from Dec. 18, 1956 to Feb. 28, 1957.

enjoin the MSDGC from discharging sewage through the Main Channel and the DesPlaines and Illinois rivers into the Mississippi River, which was the source of water supply for the city of St. Louis.

The suit resulted in the classic studies on stream purification made in 1899–1900 and reported by T. J. Burrill at the first meeting of the newly organized Illinois Section of AWWA just 50 years ago. The studies showed that even though the sewage poured into the stream from Chicago was enormous—the output of 1,500,000 people and an approximately equal amount from industries—90 per cent of the organic matter disappeared before Peoria was reached, 150 mi from Chicago. There was a slight uptake beyond Peoria caused by the waste from that community, but at Grafton, 318 mi from Chicago, there was not the slightest evidence of pollution, bacterial or otherwise. The court found that St. Louis suffered no damage, because sewage output from the Chicago area never reached the St. Louis intake.

Suits to Enjoin Diversion

Opposition to diversion increased from 1910 and culminated in a suit by the lake states to enjoin the MSDGC from taking water from the lake. The US Supreme Court on Apr. 19, 1930, handed down a decree which limited diversion to 6,500 cfs until 1936; then 5,000 cfs until 1939; and to 1,500 cfs thereafter. The decree also imposed on the MSDGC a schedule for completion of a sewage treatment plant which had been planned, together with the necessary pumping stations, intercepting sewers, and outlets to the canal system.

Sewage Construction Program

A sewage treatment program was, in fact, already in progress, and, although delayed by the war years and the depression, by December 1949 the sewage treatment plants of the MSDGC were able to provide complete treatment for practically all the sewage pumped to them.

The present capacity of the four major works is 1,286 mgd. Table 3 shows the results of sewage treatment for the period 1938–57.

Oxygen Conditions

The effect of the program of the MSDGC is best shown by studying the oxygen conditions of the waterway in the summer months. Table 4 shows the flows and diversion for the summer months only for 1935–58. Discharges at Lockport are somewhat higher than the annual average owing to the MSDGC policy of reserving a part of the diversion for use during the critical summer months.

TABLE 3

Sewage Treatment by MSDGC, 1938–58

Year	Sewage Treated *bgd*	Solids		BOD				
		In Raw Sewage *tons/day*	Removed *tons/day*	Raw Sewage *1,000 lb/day*	Raw Sewage Population Equivalent *thousands*	Effluent *1,000 lb/day*	Reduction *per cent*	In Lockport Canal *1,000 lb/day*
1938	0.568	301	99	469	2,913	150	68.1	685
1939	0.670	394	150	607	3,641	139	77.1	441
1940	0.925	621	360	982	5,894	342	65.2	361
1941	1.064	730	433	1,085	6,512	496	54.2	411
1942	1.032	733	398	1,116	6,694	495	55.5	417
1943	1.048	696	391	1,099	6,594	533	51.6	457
1944	1.024	757	412	1,192	7,150	599	49.8	418
1945	1.026	773	487	1,131	6,786	417	59.5	312
1946	1.023	818	573	1,243	7,503	400	67.8	290
1947	1.098	824	581	1,206	7,271	392	67.5	320
1948	1.065	842	642	1,213	7,279	284	76.6	202
1949	1.064	824	658	1,218	7,309	251	79.3	193
1950	1.124	821	714	1,220	7,322	144	88.2	134
1951	1.143	822	746	1,233	7,394	92	92.5	115
1952	1.113	786	716	1,180	7,077	75	93.6	103
1953	1.104	742	628	1,215	7,340	127	89.6	113
1954	1.171	781	648	1,236	7,417	147	88.1	125
1955	1.183	876	722	1,314	7,885	182	86.1	105
1956	1.150	938	773	1,349	8,091	192	85.8	119
1957	1.231	862	694	1,279	7,672	185	85.6	155
1958*	1.120	847	743	1,201	7,205	120	90.2	135

* Ten months' average.

According to available data, the summer averages for the dissolved oxygen concentration (DO) at Lockport were all low during the first quarter of the century. Only in 1922 was the oxygen depleted completely. In 1939, with the final reduction in diversion to 1,500 cfs, the DO concentration

at Lockport again fell to zero and it remained at that level for 8 years, after which a residual of 0.1–0.6 was maintained (Fig. 2).

The effect of plant construction and improvements at Chicago on the waterway is perhaps better reflected by the oxygen condition at Smith's Bridge. Oxygen was present at this station every summer and increased in concentration as the several steps were completed in the program to reduce the biochemical oxygen demand (BOD) in the effluent from Chicago.

Beyond Smith Bridge, the addition of DO by passage over dams, flow by the tributaries (Table 4), reaeration from the atmosphere, and the natural tendency of the stream to purify itself, are all factors in maintaining a desirable oxygen balance as far as Peoria. Table 5 shows the oxygen conditions of the waterway at 10-year intervals. The year 1939, the first year under the present limitation of 1,500 cfs, is inserted. The results show a progressive increase in DO at Lockport and Smith's Bridge and a corresponding decrease in BOD coincident with BOD removal at the treatment works at Chicago.

TABLE 4

*Diversion, Pumpage, Rainfall, and Discharge in Illinois Waterway in Summer**

Year	Lockport Discharge *cfs*	Domestic Pumpage *cfs*	DesPlaines Runoff *cfs*	Net Diversion *cfs*	Rainfall at Chicago *in.*	Rainfall at Peoria *in.*	Peoria Discharge† *cfs*
1935	7,800	1,669	0	6,128	14.9	13.6	17,000
1936	7,000	1,818	71	5,109	14.5	14.5	10,000
1937	7,200	1,783	11	5,373	11.0	9.9	10,800
1938	6,900	1,728	92	5,058	18.1	18.2	16,300
1939	3,200	1,770	7	1,214	9.8	13.6	8,500
1940	3,400	1,735	43	1,606	6.9	8.3	6,000
1941	3,700	1,812	43	1,856	11.9	12.0	6,900
1942	3,500	1,682	106	1,737	14.6	14.2	9,600
1943	3,800	1,747	134	1,916	13.3	11.6	15,400
1944	3,300	1,764	96	1,488	8.8	11.8	8,800
1945	3,600	1,679	249	1,689	18.6	14.7	12,100
1946	3,600	1,734	99	1,784	8.8	13.9	10,500
1947	3,600	1,766	249	1,574	14.7	12.6	14,300
1948	4,000	1,792	51	2,160	11.4	14.0	9,100
1949	4,200	1,817	103	2,233	12.4	11.1	7,600
1950	4,100	1,752	125	2,179	17.2	15.2	12,100
1951	3,900	1,718	116	2,111	18.0	15.7	16,900
1952	4,000	1,786	147	2,071	11.6	14.6	13,100
1953	4,100	1,890	132	2,048	11.7	13.5	9,300
1954	3,900	1,899	240	1,723	16.5	19.7	11,400
1955	3,800	1,988	194	1,604	12.7	11.2	10,400
1956	3,900	2,004	164	1,684	9.8	10.5	8,000
1957	3,700	1,987	239	1,462	20.2	7.8	15,000
1958	3,700	1,915	236	1,515	14.2	19.8	18,600

* Summer average for June–September.
† Pekin discharge after 1948.

Future Dilution Requirements

Although improvement in the oxygen conditions in the waterway has been favorably effected by the program of

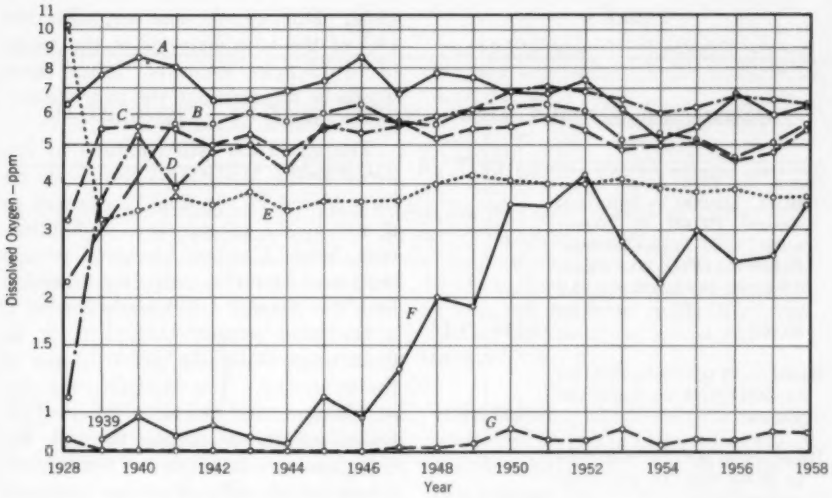

Fig. 2. Dissolved Oxygen Content in Illinois River for Successive Summers, June–September

Curves represent data for the following points: A, *Peoria;* B, *Henry;* C, *Lacon;* D, *Morris;* E, *discharge at Lockport;* F, *Smith Bridge; and* G, *Lockport.*

TABLE 5

Summer Oxygen Conditions in Illinois Waterway at 10-Year Intervals

Year	Lockport Discharge *cfs*	Sewage Treated		Oxygen Conditions								Peoria Discharge* *cfs*
		Total *cfs*	Removal *per cent*	Lock-port	Smith Bridge	Morris	Mars. Upper	Henry	Lacon	Peoria	Pekin	
				DO—ppm								
1928	10,300			0.3	—	1.1	1.2	2.2	2.4	6.4	4.8	16,700
1938	6,900	940	66.5	0.2	—	—	5.3	—	6.0	6.7	—	16,300
1939	3,200	1,148	78.0	0.0	0.3	3.6	4.4	—	5.5	7.6	—	8,500
1948	4,000	1,667	74.0	0.1	2.0	5.9	5.1	5.7	5.2	7.7	6.7	9,100*
1958	3,700	1,773	91.2	0.5	3.5	6.4	5.5	5.7	5.5	6.3	6.1	18,600
				5-day BOD—ppm								
1928	10,300			14.1	—	8.8	6.4	4.7	4.5	3.0	6.1	16,700
1938	6,900	940	66.5	16.3	—	—	—	—	5.6	3.3	—	16,300
1939	3,200	1,148	78.0	28.4	12.1	3.9	4.1	—	6.9	4.7	—	8,500
1948	4,000	1,667	74.0	10.4	4.4	4.7	3.7	6.9	5.4	5.4	6.5	9,100
1958	3,700	1,773	91.2	7.5	7.4	4.1	4.5	5.7	6.4	5.6	6.0	18,600

* Pekin discharge after 1948.

TABLE 6

Summer Dilution Requirements at Lockport

Basis of Requirement	Diversion *cfs*	DO at Lockport *ppm*
Based on 1958 data: 5-day BOD, 120,000 lb industrial wastes, 10,000 lb; storm water and miscellaneous, 80,000 lb; DO in lake water, 8.0 ppm; DO in effluent, 5.0 ppm; DO from aeration, 50,000 lb	4,730	4.2
Based on 95 per cent reduction in BOD with no industrial wastes	2,400	1.9
Based on 90 per cent reduction in BOD with no industrial wastes	4,400	3.9

the MSDGC, it is apparent that sewage treatment alone will not maintain completely aerobic conditions at the present restricted flow. Table 6 shows the dilution requirements and DO at Lockport if the ultimate (20-day) BOD of the effluent from Chicago is to be satisfied during the summer months.

Beyond Lockport the pickup of DO is rapid (Table 5). Diversions such as those indicated would assure sufficient DO to support fish life in the waterway under the worst summer conditions. During cold weather, when the DO of the lake water is in the range of 10–13 ppm, somewhat lower flows would be required and the annual average diversion would be lower.

The waterway will continue to improve as the MSDGC continues its efforts to reduce the load discharged to it and as the communities and industries below Chicago complete sewage treatment facilities. Greater diversion than the present 1,500 cfs is needed if a favorable oxygen balance is to be maintained along the entire course of the waterway. The MSDGC, the city of Chicago, and the state have again joined efforts to obtain, through the Congress, an additional 1,000 cfs to determine the effects of the increased diversion on the levels of the lakes, navigation, and the oxygen balance of the stream. It is to be hoped that approval will be obtained from both the legislative and executive branches of the government to keep the waterway in acceptable condition.

Acknowledgments

The authors wish to express their appreciation to the laboratory staff for their efforts in obtaining the analytical data used and to the MSGDC trustees, William A. Dundas and H. P. Ramey, who are responsible agents for MSGDC activities.

Municipal Water Rates and Rights Litigation

Edward F. Taylor

A contribution to the Journal by Edward F. Taylor, Taylor & Smith, Attorneys, Redlands, Calif. This paper originated as part of a report presented to the convention of the National Institute of Municipal Law Officers, Chattanooga, Tenn., by the author, as chairman of the Committee on Municipal Water Problems, and published in the 1959 NIMLO Municipal Law Review. Another portion of the report was published in the July issue of the Journal.

THE law is settled that a municipal corporation owning its plant and furnishing water to the public must charge just rates. The utility is not required to supply water at cost; it may earn a fair profit. Municipalities cannot select patrons arbitrarily but must serve all who apply on equal terms and at reasonable rates. This is as far as the rules of common law seem to have gone. They do not require absolute uniformity of rates, nor do they forbid discrimination by the charging of lower rates for one group of consumers than those exacted of others. The courts will not interfere with the collection of rates established by the legislative body unless they are arbitrary and amount to the taking of property for public use without just compensation. This attitude is evident in two major rate cases decided this year.

In *Hagerstown* v. *Public Service Commission* (*1*), the city protest that the Maryland Public Service Commission wrongfully refused to include certain factors in the water rate base for consumers outside its corporate limits was denied on appeal. It was concluded that the commission had not been arbitrary in excluding the cost of water mains, which subdividers were compelled to pay in order to secure city service, charges for fire hydrants and connections, and federal grants in connection with certain WPA water main projects.

In *Tax Review Board* v. *Weiner* (*2*), it was decided that, where water meters were not registering, the city was entitled to bill for the excess water used in prior years. Philadelphia was allowed recovery on the basis of estimated consumption. This was computed by multiplying the average daily water use on each property by the number of days the original meter was not registering. If the consumer believes that the estimate does not fairly show the amount of water consumed, the burden of proof is on the water user.

A federal court did find, however, that rates charged to a city by the federal government were not reasonable in *Rank* v. *Krug*, a significant case on its way to the US Supreme Court. The federal government must comply with state law, and the rates it charges must be fair, the court held. Fresno alleged that federal rates to certain irrigation districts were lower than those that the city paid for water for domes-

tic and municipal purposes. The court ruled in favor of Fresno.

Although local units in many states, such as California, are not subject to utility rate regulation, some states are moving in this direction. The Wisconsin Public Service Commission has the primary duty of seeing that all services, whether privately or municipally owned, charge the lowest rate commensurate with proper service (*3*).

Water Rights Problems

The stake of municipal government in modern water legislation is greater than that of any other user. Most of the nation's increase in population since 1950 has occurred in the cities and their suburban areas. In fact, about 60 per cent of the population resides within central cities of 50,000 population or more.

The use of water has created problems for mankind since the dawn of history, and lawmakers have over the centuries put their minds to the task of finding solutions.

In 1900 BC the Code of Hammurabi codified laws that had already been in existence for centuries, including provisions for irrigation and flood control. The aqueducts that supplied Rome with water during the time of Christ, some of which are still in existence, and the great irrigation systems of the Nile are ancient forerunners of today's Colorado River developments and the California Water Plan.

The aims of rules for the use of water are to determine who may use the available water and in what quantity, how the water may be used, and the kinds and amounts of wastes that may be emptied into the water supply.

The areas affected by a lack of usable water are presently causing the greatest concern. Many areas that had ample water in the past now face shortages from increasing population, industrialization, and irrigation demands.

There is grave doubt that common-law water rights doctrines, prevalent in the eastern states, are applicable in to current conditions. These common-law doctrines are often invitations to litigation, as is certainly true of the doctrine of riparian rights, which cannot be applied with any degree of certainty. Concepts of water rights that grew up in a primarily agricultural society with no real shortages are unsuited to modern urban use when demands are immense. No city can supply its people on the basis of paramount riparian rights unless it owns all the land abutting a stream within its limits.

The need for reliable and unpolluted supply has led to heavy overdraft and ruining of ground water resources by municipal, industrial, and agricultural users. Moreover, the laws applicable to ground water are based on the antiquated distinction between water of definite underground streams and percolating waters. This distinction has been denounced by ground water hydrologists as having no scientific basis (*4*). Nevertheless, Texas and California have adhered to the historical distinction in the face of prodigious developments of ground water. They have not followed the intelligent lead of such states as Kansas, Idaho, Nevada, Oregon, Utah, Wyoming, and North and South Dakota, which have rejected the distinction (*5*).

The 21 western states have enacted into law a policy that their people have a paramount interest in the use and development of water, both surface and underground, and that the state should guide that development and use for the greatest public benefit, without waste.

Nine of these western states, however, retain the riparian doctrine, modified by the rule of reasonable use, and simultaneously recognize rights of appropriation and prescription.

As a result of the indifference and halfway measures adopted in many jurisdictions, municipal lawyers are disturbed by the question: What chance is there for correlation of rights in ground waters or streams in jurisdictions that follow common-law doctrines, or, for that matter, in jurisdictions in which litigants have ignored filing procedures under prior-appropriation statutes and proceed in private suits to establish vested rights which they intend to exercise without regard to the public welfare?

At the outset it should be understood that the substitution of systems of prior appropriation for present systems is not necessarily a universal cure for water ills. There may be no need for a wholesale revision of water rights where the difficulty can be met by legislative action directed to water-short areas or where changes in technology and distribution assure ample supply (*6*). For instance, the Water Resources Commission of Connecticut said that, although the development of riparian laws may not keep pace with needs, further specific legislation does not seem necessary at present.

No statutory system of water law will work without an efficient system of administration. Many of the earlier statutes need revision to meet modern conditions (*7*). In order to bring about maximum beneficial utilization of existing supplies, legislatures are transforming water rights law and accepting state management of water resources.

Half of the states have enacted comprehensive laws affecting the use of water resources or have appointed special water study commissions. In some states, such as Alabama, organized movements stalled when the legislature failed to appropriate funds.

'Model Water Use Act'

One approach to uniformity is the "Model Water Use Act" (*8*). It provides for a state commission and incorporates the best features of various state and local laws. Its aim is comprehensive and paramount control over all the water resources of the state. The commission's duties are planning for beneficial water development, regulating uses in accordance with the "act," and dealing with the federal government and other states. Uses of ground water, surface streams, and lakes regulated under the "act" include withdrawals, use, and storage. Uses are classified as "preserved" or "permitted." A preserved use, if reasonable and consistent with the public interest, will be protected from interference by subsequent permitted uses, so long as it continues to be beneficial and is not terminated by nonuse for a period of 3 years. A permit is granted if water is available and the proposed use is beneficial and does not impair existing preserved, domestic, or permitted uses. A permit is granted for a definite period. The water right does not depend on the law of the state prior to the effective date of the "act." To guarantee constitutional "due process," the "act" requires hearings by the commission, the right of appeal to state courts, and compensation for actual damages to property rights by actions against permit holders.

Following the lead of the West, many states have adopted new statutory law. In some states, planning boards have been created, ranging from

ineffective advisory boards to powerful control agencies responsible for all plans for water use. The trend is toward overall economic control of land planning and water use. Effective administration is the main problem at present, but much is being learned through trial and error (*9*).

Kentucky created a water resources study commission that includes a municipal representative. The function of the commission is to study all agencies of the state government whose activities have an effect on the development and use of Kentucky's water resources and to formulate new laws and improved administrative machinery where necessary. Tennessee's new water resources division is responsible for a program of conservation, protection, and development of the water resources of the state and the study of a long-range water resource policy. It will explore through public hearings the contrasting viewpoints of all competing users of water and determine their respective needs (*10*).

The Texas legislature set up a water development board to administer funds derived from the sale of $200,000 in state bonds authorized by a constitutional amendment for water conservation and supply. Six members are appointed by the governor, with the advice and consent of the senate. The act provided that the board may give financial assistance to the political subdivision by the purchase with monies out of the state's water development fund, of bonds or other securities (*11*).

State Progress

The Texas Water Resources Planning Division, headed by the State Board of Water Engineers, is developing an inventory of the quantity, quality, and location of all surface water. The division will work with municipalities in a joint program of mapping watersheds and studying beneficial use (*10*).

Oklahoma is considering a completely new water law recommended by the Oklahoma State Water Study committee (*10*), and Louisiana has set up a water resources study commission of fifteen members to study the state's water policy, the need for revisions, and the manner of administration of the revised policy.

A bill before the South Carolina legislature provides that all unappropriated surface waters are public waters. Under its police power, the state is to control and develop water for all beneficial purposes, but no person will be deprived of a vested right (*10*).

In an attempt to eliminate duplication, North Carolina now gives the Department of Conservation and Development the sole responsibility for research in connection with water resources and for the maintenance of the inventory of water resources (*10*).

In Kansas, the governor appointed a nonpolitical resources commission which is somewhat dominated by agricultural interests in that the administrative work prepared for this agency is accomplished under the supervision of the chief engineer of the water resources division of the State Board of Agriculture.

At last session, Kansas lawmakers adopted several resolutions to ask Congress to support flood control and soil conservation projects in Kansas. A Senate Concurrent Resolution could amend the state constitution to permit the state to engage in flood control works and the conservation and development of water resources. Kansas now is prohibited from carrying on any work of internal improvement.

Delaware's general assembly rejected a bill that declared: "Water occurring in any watercourse, lake, aquifer, or other natural water body of the state is declared to be public waters and public wealth of the state . . . , and the control, development and use of water for all beneficial purposes shall be in the state." A water resources commission would have regulated the taking of water (*10*).

The Nebraska legislature has taken a step toward regulating underground water. One bill requires owners to register each irrigation well with the state engineer, giving any information the state engineer may require. The second bill provides spacing regulations of 600 ft for irrigation wells in most cases. In Illinois, the 69th General Assembly created a study commission on the water and drought situation and ordered it to make a thorough study (*12*). Iowa has a comprehensive new act which stamps both surface and underground waters as public wealth and establishes a permit system. Permits are required from any municipal corporation which increases water use in excess of 100,000 gpd or 3 per cent more than the previous daily high.

The most drastic changes in water policy seem to be occurring in the South. Mississippi has progressed from rigid adherence to the riparian doctrine to a policy of prior appropriation for surface waters. With the approval of the Water Conservation Law, Mississippi joined ranks with the seventeen western states that follow the doctrine of appropriation in one form or another. To establish their right to continue to make beneficial use of water, all users, including municipalities, were required to apply to the Mississippi Board of Water Commissioners before Dec. 31, 1958 (*21*). One writer suggests that the state's new water law is an unconstitutional attempt to abolish, without compensation, vested property rights of riparian proprietors.

The definite need for a curb on the ever increasing waste of water supply and the assurance of good water daily to municipalities and those investing in industry led certain members of the General Assembly of South Carolina to propose a modified form of prior appropriation. This proposal has met with considerable opposition from some sources and has failed of passage each time. The last three sessions of the legislature granted to certain municipalities and one industry the right to divert fixed amounts of water daily. There is fear that the supply of certain streams may be entirely allotted by legislative action.

California's legislature enacted only two bills affecting municipal water rights. One permits portions of a city to be included within different municipal water districts. The other preserves the identity, legal existence, and powers of any public corporation or public agency included in, added to, or annexed to another county water district.

Air-Conditioning Restrictions

There is a growing awareness of the increased water consumption caused by air-conditioning installations. Failure to conserve water during periods of shortage may result in heavy mortgaging of community water supplies.

One of the effects of air conditioning has been the passage of laws to control practices which waste and pollute water. The need for regulation was shown by a scientific study conducted

in Ames, Iowa, in which it was found that air-conditioning use is obviously increasing, and its effect on the water utility could only grow. If residential installations mushroom as anticipated by the air-conditioning industry, communities may not be able to support the added demand. Air conditioning also creates the problem of idle standby facilities. In Ames, Iowa, facilities serving air conditioning are idle and unproductive for 90 per cent of the year.

Based upon the model ordinance prepared by AWWA, the Ames ordinance states that new installations with a capacity of 2 tons or more must provide for recirculation of the cooling water. The ordinance is not retroactive and does not apply to existing installations during their normal service lives, but it will apply at the time of alteration or replacement (*14*).

A nationwide survey of power companies and water utilities indicated marked increases in the number of air-conditioning units, particularly in the South. Because of air-conditioning systems for homes and commercial and industrial installations, which, in the lattter two, have become a competitive necessity, power and water companies expect staggering demands on their facilities. Northern and central California shows a sharp increase in the number of units. Three of the newest 8–12-story buildings in downtown San Francisco are completely air conditioned, and, of course, air conditioning of factories is becoming increasingly common.

Five cities require licenses of those who install air conditioning or refrigeration. Shreveport, La., Kansas City, Mo., Bismarck, N.D., South Saint Paul, Minn., and Detroit, Mich., have adopted ordinances of varying strictness and require fees.

In regulating air conditioning, cities either require permits to install systems or permits to operate. In Manhattan, Kan., one needs an installation permit only if water is to be used from a source other than the public supply. Highland Park, Mich., specifies an annual inspection of each installation by the city engineer (*15*).

The filing of written claims as a prerequisite to suing cities in actions involving water rights is under scrutiny in some jurisdictions. The time involved in the appropriation of ground water may warrant extending the time limit for filing claim notices. The Kansas board, however, cautions against hasty limitation of a law which serves a sound purpose by permitting investigation of good faith administration of claims, and the prevention of unfair surprise to the prejudice of government. This is especially true at a time when municipalities are increasingly engaged in water litigation.

Many of the state water appropriation laws list preferential uses. Given a high priority after domestic uses are municipal uses, which are seldom defined. Because municipal government serves diverse water users, some groups seek to subdivide municipal uses into domestic and industrial categories.

As the Kansas Water Resources Board has pointed out, the large number of water uses dependent upon municipal supply defy fine distinctions. "To subclassify the various uses within any municipality is to set up the standards of one class of state inhabitants and to require all development to conform to that standard without regard

to the complexities of modern urban organization," the board said.

Whether legislatures should make any detailed classification or subdivision of municipal uses is highly questionable. Certainly the status of cities serving water for industry or agriculture would be unsettled if multiple priority distinctions were applied to water rights (*16*).

Progress toward sensible, modern water legislation throughout the nation has been heartening. Legislation that promotes the development of new supply and accomplishes conservation and the maximum beneficial use of existing supplies merits vigorous support.

Suits Involving Federal Claims

The federal government's assertion of paramount rights to waters in several western states is regarded by many municipal attorneys as a direct threat to the integrity of existing water rights. It is feared that the United States seeks to invalidate rights already established under state law, and attorneys therefore vigorously oppose the federal theory that the government may elect to develop reservations at any time with no regard whatever for recognized rights. That these fears are justified has been indicated in a number of court decisions which have left unsettled the matter of federal claims in derogation of state water rights.

Pelton Decision

A landmark in the struggle between federal and state authorities for the control of western water resources, the Pelton decision (*17*) held the United States possesses a paramount proprietary interest in all unappropriated waters flowing through certain reserved lands. The United States planned to place a dam between a government reservation of public lands for power sites on the one side of the river and an Indian reservation on the other. The court held that the Desert Land Act * does not apply to waters on government reservations. The Federal Power Commission was given exclusive jurisdiction in the granting of a license for the use of such water, and Oregon was given no rights.

Municipal lawyers believe the Pelton decision may have momentous effect. Hundreds of water rights that municipalities, farmers, and industry acquired under the state laws of appropriation might be held void as against a future federal need, because the water comes from federal reservations. A widespread feeling of instability has therefore resulted.

Certain decisions involving Indians created an exception to the governmental policy of recognizing the control of state water laws over nonnavigable streams. This control was denied in order to enable the federal government to fulfill its obligations to the Indians. Should the vested appropriative rights of the western states, some more than 100 years old, be wiped out by mere executive action? If the Pelton decision were merely another exception, there might be less cause for alarm. There is a feeling, however, that the United States is not thinking

* The Desert Land Act, passed in 1877, provides:

"All surplus water over and above such actual appropriation and use, together with the water of all lakes, rivers and other sources of water supply upon the public lands and not navigable, shall remain and be held free for the appropriation and use of the public for irrigation, mining, and manufacturing purposes, subject to the existing rights."

only of the Indian or providing for military installations, but is asserting a paramount proprietary right to the unappropriated, nonnavigable waters flowing across reserved public lands. The Pelton case may have profound effect on the economy and well-being of the West. Justice Douglas dissented in the Pelton case, on the ground that the public land laws had transferred the control of such waters to the states long ago.

Santa Margarita Case

In claiming water rights in California, the federal government stands in the same position as any other party, a federal judge has ruled. Judge James M. Carter's comprehensive pretrial opinion in the Santa Margarita case declared that the rights of the United States to waters of the Santa Margarita River for use in Camp Pendleton would be determined by the same rules as apply to any private individual, and that the extent of the rights of the United States would be determined by state law.

Although the court said the United States has the power to make reservations of public lands or waters in spite of state law, it determined that this power can only be exercised by Congress. The court held specifically that neither the Solicitor General of the United States nor the Navy has been delegated any such power by Congress. In fact, he found that every congressional enactment on the subject expressed the clear intent that state laws should apply in the case of the Santa Margarita River.

Two important rulings in the 120-page pretrial opinion, which ruled on numerous motions, are:

1. Rights of the United States are to be determined under state law, and as a riparian owner, it has no right to use the waters of the Santa Barbara Margarita River outside the watershed of that stream.

2. The United States has no special right to use water on Camp Pendleton by reason of its sovereign status and has acquired no rights by inverse condemnation.

In claiming paramount rights neither riparian nor appropriative and above state law, the government advocates a new system of water law, for there is no federal water rights law, either statutory or judicial.

The federal claims are based on extensions of the Pelton dictum and would destroy or impair many private water rights and prevent additional development of water resources.

Hearings held in 1958 before the House Committee on Interior and Insular Affairs were focused on the attitude of the federal government. Chairman Clair Engle urged congressional investigation into the necessity of suing some 6,000 defendants (everybody in the watershed) in order to determine the title to the water. As a result of the broadening of the issues in the case, the complaint grew from seven to 72 pages.

Colorado River Basin

A 6-year-old Colorado River water suit (*18*) rumbled to an end after 132 trial days before Simon H. Rifkind, special master for the US Supreme Court. In its original complaint against California, Arizona claimed rights to 2,800,000 acre-ft/yr from the 7,500,000 acre-ft/yr allocation in the 1922 Colorado River compacts. Arizona asks a decree cutting California's annual diversion from the river by 1,000,000 acre-ft. To grant Arizona's demands for 30 per cent of the Cali-

fornia claims by appropriation and contract would be to reduce the water supply of 83 cities now depending upon the Colorado River.

The United States and five states, Arizona, California, Nevada, New Mexico, and Utah, presented evidence of their respective bids for water in the lower Colorado River basin. Total claims were 9,962,000 acre-ft/yr, including California, 5,362,000 acre-ft, Arizona, 3,800,000, and Nevada, 800,000. There were additional claims by the United States for water for Indian Reservations and national parks.

Federal claims of water for Indians would defeat the state's basic claims. The government is asking for 1,700,000 acre-ft in diversions. At least one reservation has no Indians on it at all, and others have only a handful. Invoking the Jencks decision, the judge forced the United States to show California certain papers in connection with cross examination. In order to allow all of its attorneys to see the papers, California set up a photocopying machine in court.

There were approximately 26,100 pages of transcribed testimony, or about 8,000,000 words, and more than 4,000 exhibits. The deadline for submitting briefs is Jun. 1, 1959. Judge Rifkind gave no indication of when he would have his report ready for the Supreme Court, which usually adopts a special master's findings.

Among needs for national parks and national monuments, the United States included water for 12 Gila monsters on the Tonto National Monument in Arizona. The record does not disclose how much water a Gila monster uses. For geese and ducks, the United States demands 2.2 acre-ft/yr—enough to meet domestic and industrial requirements for 10–12 people. James H. Howard, Counsel for Metropolitan Water District, was inspired to write:

OWED TO A WATERFOWL

It seems just a trifle absurd
That, in water consumption, a bird,
Though lesser in weight,
And more waddling in gait,
Equals almost two men and a third.

Nevada

The Hawthorne Ammunition Base, a federal installation using underground water, at first decided to comply with the laws of Nevada by making application for its water appropriations. Before the state engineer approved the applications, the Pelton and Ivanhoe decisions came down. Immediately the United States claimed it was not required to comply with Nevada law. And the Navy withdrew its applications. Nevada filed an action seeking declaratory judgment (*19*).

Dismissing Nevada's complaint, the district judge said: "There is no mandate in constitutional, statutory, or decisional law that compels the federal government to bend its knee to this type of state law and regulations." Noting the decision of the Supreme Court in the Ivanhoe case, the judge said: "A state cannot compel use of federal property on terms other than those prescribed or authorized by Congress." National defense became a factor, as he added: "A court should hesitate to impede the lawful and logical functions of the Department of the Navy exercised in what it has been stipulated is a majority military installation."

Six states supported Nevada in the case. The California Department of Water Resources filed a brief as *amicus curiae* upholding Nevada's position in which the states of Nebraska, North Dakota, South Dakota, and Wyoming

joined. Washington joined in the briefs filed by Nevada.

The court relied heavily upon *McCulloch* v. *Maryland* (*20*), from which it quoted:

> No trace is to be found in the Constitution of an intention to create a dependence of the government of the Union on those of the states. . . . To impose on it the necessity of resorting to means which it cannot control, which another government may furnish or withhold . . . is incompatible with the language of the Constitution.

Ivanhoe Case

The Ivanhoe case and three companion cases concerned water supply projects in California constructed by the US Bureau of Reclamation. The excess-land provisions of the federal reclamation laws, included in the repayment and water service contracts executed by the districts, were held valid. The determination of the validity of these provisions involved questions of whether federal law requires that state law be followed, the authority of state public agencies to comply with the contract provisions, and whether the latter are unconstitutional as a denial of due process and equal protection under the law.

The California Supreme Court's theory of a trust, in which the United States assumes the same obligations and responsibilities as the state, was also upset, as the US Supreme Court reversed the California Supreme Court by a vote of 8–0.

The opinion regarded the acquisition of water rights and the operation of a federal reclamation project as two different things. The United States is required to comply with state law in the construction and operation of a reclamation project only if it is also necessary to acquire water rights. But Congress did not intend to override a long-established national policy embodied in the excess-land provisions, the court said.

The power of the federal government to impose reasonable conditions on the use of federal funds, property, and privileges was upheld. About the denial of water for any land in excess of 320 acres, the court said:

> It is a reasonable classification to limit the amount of project water available to each individual in order that benefits may be distributed in accordance with the greatest good to the greatest number of individuals. The limitation insures that this enormous expenditure will not be in disproportionate share to a few individuals with large land holdings. Moreover, it prevents the use of the federal reclamation service for speculative purposes. In short, the excess acreage provision acts as a ceiling, imposed equally upon all participants, on the federal subsidy that is being bestowed.

The court rejected the argument that federal contracts fail to state the total sum owned by the contracting agency. As interest is not charged on the amount due, and because existing law requires a credit to be given toward construction charges, the contracting agency is adequately potected and does not have to pay more than its share, the court reasoned. Although the contracts fail to provide for a transfer of title to the works, the court considered it reasonable for the federal government and the contracting agencies to defer the question of title passage to another day. Only the distribution facilities—not the main project works—are involved, the court concluded.

A petition for rehearing and clarification is now before the US Supreme Court (*21*). The petition states:

These decisions seemingly represent an unjustifiable extension of federal power in disparagement of both the legislative and judicial authority of the states. In reversing the Supreme Court of California's holding that the contracts were invalid, the court points to no federal enactment which imposes the contracts, and expressly disavows any intent to determine whether Congress could constitutionally do so. . . . Unanswered questions of state law remain and should be expressly left open for final decision by the Supreme Court of California.

Washington

An interesting case arose when Tacoma sought a license from the Federal Power Commission to build two dams for the production of power on the Cowlitz River, a navigable stream in Washington (*22*). One of these dams will flood a fish hatchery owned and operated by the state of Washington.

Washington's Department of Fish and Game contends that state law prohibits the construction of dams on this river without state approval. The state refused approval because of harm to fish and destruction of the fish hatchery. The commission issued a license, however, which was confirmed by the Federal Court of Appeals for the 9th Circuit. The US Supreme Court refused to alter this decision.

In the meantime, Tacoma brought a suit to validate its bond issue. The Washington State Supreme Court decision that the city had no authority to take state land, such as the fish hatchery, by eminent domain, was reversed by the US Supreme Court, which refused to consider whether the specific language in the Federal Power Act gives the city the authority to condemn state land. The clear conclusion of the decision, however, is that a city created under the laws of the state can, under federal law, be given such authority in carrying out a federal license.

The vital question of federal refusal to abide by state water law arose in the Blue River case in Colorado. It affected the water supply of Denver. Despite the investment of millions of dollars by the city for a water source in the mountains, the United States claimed the water and denied that it was subject to normal appropriations by the city. The issue was finally resolved by compromise.

When Orem City, Utah, and the federal government each filed applications to appropriate the same water, the city's claim was denied by the court. It found the United States' right of appropriation had been perfected long before the city applied (*23*). The fact that the federal government had changed its point of diversion did not affect its right, because it had applied to the state for approval of the change.

Suits Not Involving Federal Claims

After a stormy, 114-day court battle over water rights, the parties in *Orange County Water District* v. *Riverside, Colton, San Bernardino, and Redlands* (*24*) are again battling on appeal. The 1957 judgment, which was in favor of the district, limited the cities' prescriptive rights to Santa Ana River water on the basis of 1951 production. A writ of supercedeas stayed execution of the injunction. The cities seek reversal on grounds that the water shortage in the district basin was caused by the drought and not by municipal pumping. They contend that the statute under which the district sued was unconstitutionally applied, that the court abused its discretion in

confining the action to the four cities and refusing to enjoin a host of other major producers from extracting water from the basin, and that an erroneous method was used to compute the cities' appropriative rights under California law.

To the cities' claim that there is no proof they are to blame for falling water tables 50 mi away, the district urged that there was enough evidence to support the court's findings of fact. One finding was that the river was the common supply for both the upstream cities and the district, despite the distance between them. The court rejected the cities' evidence that evaporation and transpiration consume great quantities of water in the river and that urbanization results in the return of greater amounts of water underground.

The need for water law doctrines geared to modern urban conditions has been stressed by the cities. Municipalities should have equal rights with overlying and riparian landowners, and not merely the rights of appropriators. They urge the logic that cities act as agents exercising their residents' paramount right as overlying owners to pump from the underlying basin. These residents may surrender their superior rights to the city, and the law should assume such a surrender when an owner elects to take water through city facilities. Because more efficient municipal operation wastes less water than private wells, it better satisfies the California constitutional prohibition against waste.

Crow Wing County Case

Minnesota brought six actions to determine adverse claims to the beds of certain lakes and connecting streams in Crow Wing County. The state alleged that it was the owner in fee simple of the lands constituting the beds of these lakes and streams. The riparian owners answered and alleged that, because the waters involved were nonnavigable, they were the owners in fee simple of the beds of these waters. The actions were consolidated for trial. By stipulation, the court limited the issue to determination of the navigability of the waters involved, and left the boundary lines between lake and stream beds and riparian lands for future determination. The importance of these cases was that the lake and stream beds involved are underlaid with valuable iron ore deposits. The court found all the disputed lakes and streams nonnavigable, and the title to the beds was therefore vested in the riparian owners, except for Little Rabbit Lake and the channel between it and the Mississippi River.

This case is significant for its interpretation of the rule of public ownership and control of waters in the state.

Utah

After Utah's Weber Basin Water Conservancy District constructed Wanship Reservoir, a landowner 35 mi downstream claimed damages for diminished flow. The substance of this complaint was that subsurface waters were part of his land and that reduction in the river flow would lower the water table and remove moisture from his soil.

Denying the owner's right to damages, the Utah Supreme Court pointed out that the demand was a riparian demand, which the Utah legislature does not recognize; the water district should not have the burden of maintaining water in the river to maintain

water levels of abutting land; to endow owners with such controls would not only impair the right of prior appropriators to use waters rightfully theirs, but would make it practically impossible to impound and use such waters.

Idaho

The necessity of proving all the elements of adverse possession to establish a prescriptive right was reaffirmed by an Idaho court (*25*), which ruled in favor of an irrigation district.

The Mountain Home Irrigation District's reservoir was supplied from Rattlesnake Creek. A private owner periodically dammed the creek to divert water to his private reservoir. The district's inspector testified that he knew of these diversions, but only broke the diversion dam when it was necessary to turn the water back into Rattlesnake Creek, and to fill the district's reservoir.

The court found the claimant had not shown the 5 years' use of the water required by statute, and no prescriptive right was established because of the district's apparent knowledge of the claimant's takings of water. The decision emphasized that: "the policy of the law of Idaho is to secure the maximum use and benefit of its water resources."

Connecticut

A contract between a water supplier in New York and another in Connecticut allocated the waters of the Mianus River, an interstate stream. The Connecticut utility's approval of the contract was attacked by the town of Greenwich. The Connecticut Supreme Court of Errors upheld the order approving the contract, because the town had not proved that the commission acted illegally, arbitrarily, or in excess of its authority (*26*).

Virginia

A town's application for permission to erect a dam across Goose Creek to increase its water supply was approved despite opposition from the county, in *London County* v. *Town of Fairfax, Va.* Estimates indicated an increase in the town's population from 1,946 in 1950 to 15,000 in 1960 (*27*). Upholding the commissioner's finding in favor of the town, the Virginia Supreme Court said that there was ample credible evidence that a public necessity or an essential public convenience would be served.

Iowa

Demonstrating that major water rights disputes can be intelligently solved by negotiation, Des Moines and West Des Moines compromised their differences over waters of the Raccoon River. The cities' agreement allowing West Des Moines to withdraw specified quantities of water was incorporated in a court decree. Des Moines had opposed its sister city's application for a permit from the Iowa Natural Resources Council to take water from the fluctuating river supply, which was often sufficient one year and insufficient the next. West Des Moines also agreed to pay Des Moines for the use of certain facilities.

Validity of Legislation

The Kansas Water Appropriation Act, under attack in the courts many times since its passage in 1945, was held unconstitutional in 1957. The district court's decision was one more step in the struggle that has been raging for years over rights to Equus

bed waters in McPherson and Harvey counties, as between farmers and several smaller cities on the one hand and Wichita on the other. Forty-eight farmers and the cities of Newton, Hesston, Sedgwick, Burrton, Halstead, McPherson, Moundridge, and Inman appealed the state's order of vested rights in Wichita. The basic issues were whether natural subirrigation constitutes a beneficial use under the Water Appropriation Act and whether landowners can have vested rights to water for that purpose.

In 1956, the US Circuit Court of Appeals, in *Baumann* v. *Smhra,* held the act valid under the Constitution. On appeal, the US Supreme Court affirmed the finding.

The current case again asserts the act violates the due-process clause of the 14th Amendment. The Baumann case involved the constitutionality of the 1945 act, whereas the current case involves the act as amended by the 1957 legislature. The outcome should be of great concern to all Kansans, because the basic state law on water rights is at stake.

New Mexico

The modern water law of New Mexico authorizes the state engineer to enjoin anyone without a permit from drilling wells.

In *State* v. *King,* King's claim that he was pumping his own waters was rejected by the court, which found he was taking from the Roswell underground basin. Surface water becomes public water in an established underground basin, the court said; no one has the right to store private water in underground basins.

Kansas

A Kansas court held that a connection charge made by a utility district is "confiscatory, unreasonable, unlawful, and void" and enjoined the district from collecting it (*29*). The district supplied water to a subdivision and agreed by contract to make certain refunds to the subdividers. To raise money for the refund, it adopted a resolution establishing a connection charge of $175 for every house in the district. The court found that the charge applied only to houses in the subdivision, not the entire district, and that it bore no relation to actual cost, and was designed only to recoup a rebate. "The trial court had the power to determine whether the connection charge was unreasonable and unfair," the court said. The court's power of review extends only to the question of fairness, however. The matter of fixing rates is exclusively legislative.

The state auditor of Kansas refused to register $20,000,000 in water revenue bonds of Water District No. 1 in Johnson County. He acted on the basis of an Attorney General's opinion that the act authorizing the bonds was unconstitutional.

The auditor was ordered to register the bond issue when the Kansas Supreme Court decided that the act does not violate the constitution (*30*). The small tax to pay preliminary expenses and revenue bonds payable from the district's water revenues does constitute a taking of property without due process.

The right given a board of county commissioners to create water districts in the public interest is not an improper delegation of power by the legislature, the court held.

Ohio

Ohio legislation requiring well drillers to keep logs and furnish a copy to the Division of Water was held to be constitutional in *State* v. *Martin.*

"It is the duty of the state to control and conserve its natural resources for the benefit of all the inhabitants of the state," the court of appeals said (*31*). It held the statute to be a reasonable exercise of police power.

Texas

Pursuant to a Texas statute, the State Board of Water Engineers denied the Southern Canal Co. application for a permit to appropriate public waters (*32*). The lower court held that the constitution and statutes of Texas gave it no jurisdiction to review and set aside the board's order.

The Texas Court of Civil Appeals held that the provision that board orders should be reviewed again and determined by a rule of evidence other than the prevailing state rule violates constitutional separation of powers. The provision purports to give the court administrative responsibility, according to the opinion. The severability theory was applied to save the rest of the statute.

In *San Antonio* v. *Bexar Metropolitan Water District* (*33*), the Texas Appellate Court approved the city's requirement that the district, at its expense, shall conform its water mains in the streets to improvements made by the city.

The court held that San Antonio had control of its streets by statute and charter and can regulate their use. The issue arose after San Antonio had annexed the area, including streets, in which the district was located.

Tennessee

In *Chandler Inv. Co.* v. *Whitehaven Utility District of Shelby County* (*34*), a subdivider within the utility district sought to contract with Memphis for water service. The utility district by statute had the exclusive franchise for water service within its boundaries and was responsible for fire protection to the subdivision, if the developer deposited $88,000 for main extensions with the right to a 50 per cent refund.

The court denied the subdivider the authority to purchase the mains from Memphis, because, in the absence of an express franchise provision to the contrary or a charter obligation, a utility district is not required to furnish water to each of its inhabitants or property owners. The right of an inhabitant to demand an extension of service is not absolute. It is determined by the reasonableness of the demand under the given circumstances and is a matter of discretion. The court pointed out that there had been no court determination that additional service was needed for the public convenience and necessity. The district is not required to lay mains at its own expense to serve the new subdivision.

Michigan

The Michigan Supreme Court resolved all constitutional questions in favor of the validity of the Michigan Drainage Law of 1956. The one legal obstacle remaining to the implementation of the plans of the Royal Oak and other South Oakland County communities for solving their drainage problem is another case currently on appeal to the Michigan Supreme Court.

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Procedure for Establishing Water Rates

Joint Discussion

A joint discussion presented on Mar. 12, 1959, at the Illinois Section Meeting, Chicago, Ill.

Privately Owned Utilities—*Clifford Fore*

A paper presented by Clifford Fore, Mgr., Illinois Cities Water Co., Mount Vernon, Ill.

THE starting point for establishing utility rates is the determination of the total annual cost of service, which includes operating expenses, depreciation, taxes, and return on the rate base or debt service. Immediately pertinent is the question of how management determines whether or not new rate schedules should be filed.

Need for New Rates

The view held by the officials of the Illinois Cities Water Co. is that publicly owned water utilities should be subject to the same regulatory conditions as privately owned utilities. These regulations would apply to accounting, service, and rates. Actually, there are only a few states in which both types of utilities are subject to the same regulations. The management of a utility knows how much the utility earns, based upon the prescribed method of accounting. It would, of course, also know the amount of earnings that the regulatory body allows the utility. When the amount earned is less than that customarily allowed, an application for new rates is made in order to increase the revenue.

This article will not deal with the controversial question involved in the determination of a fair *rate base*, which is governed by the laws and decisions of the state involved. Neither will it deal with the factors that are used in the determination of the *rate of return*, which will vary according to the laws of the state. The lack of specific definitions for the two terms does provide grounds for argument in rate cases of privately owned utilities, and it leaves the regulatory commission with considerable freedom in making its rulings. There is not much argument about the rate base, but there is a controversy about the rate of return.

The author's company obtained rate increases in 1948, 1950, 1956, and 1957, and it will probably be necessary to apply for another increase in 1959. At the 1958 Annual Conference of the AWWA in Dallas, certain resolutions were adopted, among them one for the purpose of setting up standards to which the various facilities of a water system should conform. Ever since its formation, the Illinois Cities Water Co. has been observing the intent of this resolution. According to the company's present plant account, 66–67 per cent has been added since its properties were purchased in 1946 and 1947.

The officers of the company, who have had some experience in the investment field, claim that the equity securities of water utilities are difficult to sell, not because of their lack of intrinsic merit but because they are not suited to the inflation that has prevailed over the past 25 years. The company properties were purchased in 1946 and 1947, shortly after the end of World War II. During the war, it was difficult to obtain materials and arrange financing. The result was that the properties were underdeveloped, and earnings were far from satisfactory. Actually, Mount Vernon, the first property purchased, was not earning its operating expenses. Fortunately, however, the people responsible for the formation of the company had credit and capital, and both were used generously during the first 15 months of operation. By that time, a rate increase was obtained and much needed improvements to the physical property made. In the summer of 1948, a bond issue was sold to a major life insurance company. Since that time, the company has become self-sufficient, chiefly by making certain plant additions, getting a rate increase, and selling securities. At the end of last year, the plant account, stated on an original-cost basis, was approximately $5,250,000. On a basis of reproduction cost new, the figure would probably be about $8,250,000, which gives some idea of the extent of the company's operation.

Utility Regulations

There are three primary differences in the regulation of privately owned and publicly owned water utilities:

1. The regulatory commission has certain rules and regulations with which publicly owned utilities under its jurisdiction must conform. Privately owned utilities have their own rules and regulations approved by the commission and in accordance with which they must operate.

2. Publicly owned utilities are free from federal and state taxes; those privately owned must pay taxes on their property—both real and personal—taxes on earnings, and taxes on capital stock, all of which adds up to a substantial amount.

3. Publicly owned utilities can finance practically 100 per cent of their capital requirements with securities, the interest on which is not subject to federal income taxes. Securities of privately owned utilities are subject to all the taxes levied on both the principle and the income. On the average, the capital costs of a publicly owned water utility are about 60 per cent of the cost of one privately owned.

There are four major divisions of activity in the operation of a privately owned utility, each of which includes many other activities. These divisions are: [1] general executive direction, [2] operations of the property, [3] accounting, and [4] financing. The executive division is primarily concerned with rate problems and pertinent background matter; rate base and rate of return seem to be somewhat like Topsy—they "just growed."

Background and Terminology

Rate regulation by commissions is about 60 years old. Prior to the development of regulatory commissions, attempts were made to control utilities by writing provisions into a franchise, and an exclusive franchise was considered a prized possession of every utility. From the growing pains of the early days of public utility development, there evolved the idea that service should be supplied by noncompet-

ing companies, but that such companies should not be permitted to take advantage of the noncompetitive aspect of their businesses to exact undue rates from the consumer. This idea took form in franchising a single company to supply one or more types of service in a specified geographical area, with its rates regulated by a state agency that became generally known as the public utility commission (in Illinois, it is the Illinois Commerce Commission).

Property Value (Rate Base)

For many years the value of physical property for rate making was based on its reproduction cost new, less depreciation. The US Supreme Court in 1898 rendered a decision in *Smith* v. *Ames* (*1*), in which the court said, "What the company is entitled to ask is a fair return upon the value of that which it employs for the public convenience." Reproduction cost theory was upset in 1944 by another decision of the US Supreme Court, made in what is generally known as the Hope Natural Gas Co. case (*2*). In that decision, the court said that each state might establish for itself a formula for determining property value to be used by the state in rate making. The court also said:

> It is the result reached, not the method employed, which is controlling. . . . By that standard, the return to the equity owner should be commensurate with returns on investments in other enterprises having corresponding risks. That return, moreover, should be sufficient to assure confidence in the financial integrity of the enterprise, so as to maintain its credit and to attract capital.

After the Hope Natural Gas Co. case, three formulas for determining property value in rate cases were established, and are still used by the states as a basis for the determination of utility rates. These are: [1] reproduction cost new, less depreciation; [2] original cost, less depreciation; [3] fair value.

Reproduction cost is determined on the basis of current prices of materials and labor—that is, what it would cost to reproduce the property.

Original cost is based on the actual cost of constructing the property, usually expressed as "the actual cost when first dedicated to public service." If the original or early records of a company are not available, estimates of the original costs are made by a person assumed to be competent; the company then submits the figures to the utility commission for review. If the figures are found to be reasonable, the utility commission will issue an order directing the company to enter the figures on its books.

Fair value is a judgment figure arrived at after consideration of the reproduction and original cost figures. To these figures, there is usually added an amount for materials and supplies and a specified sum for working capital; the result is called the "rate base." Some states, erroneously in the author's opinion, do not allow working capital, asserting that it is adequately provided for by cash set aside for taxes.

Allowable Return

After the rate base has been established, the rate of return is applied to this figure, which in turn produces the allowable return or earnings the company is to receive. Irrespective of the method used in the governing state, the allowed return will not differ appreciably; nevertheless, it should conform to the decisions of the courts. During the past 50 years, rate base has been the most controversial item in

the determination of public utility rates. Some contend that the rate base should consist of the cost of the properties devoted to public service, less accrued depreciation, plus an allowance for working capital (this determination is called the investment method or prudent-investment method). Others contend that it should consist of present fair value of the properties used and useful in the public service, plus working capital (fair-value method). Working capital in each case consists of two elements: cash, and materials and supplies.

For many years the Illinois Commerce Commission used fair value as a basis for rate making, but in about 1949 it began using original costs plus working capital, and materials and supplies. This led to an appeal to the Supreme Court of Illinois for a decision in the case of *Illinois Bell Telephone Co.* v. *Illinois Commerce Commission* (*3*). In the 1952 decision the court said:

> The statutory language that rates and charges made by a public utility shall be "just and reasonable" has remained unchanged since the Public Utilities Act of 1913. In construing the statute, this court held that the commission must use a rate base which represents the present fair value of the utility property, arrived at after full and proper consideration of reproduction cost, and a reasonable return, based upon an appraisal of the opportunities available for investment in other enterprises.
>
> It is the commission's duty, therefore, to consider the record in this case, to hear such additional evidence as may be necessary, and to enter findings and conclusions all in accordance with the views expressed in this opinion.

After the above decision, the Illinois commission returned to fair value as a basis for rate making.

In the absence of a definition of "present fair value," it is exceedingly difficult to know exactly what it means. All sorts of meanings are assigned to it, ranging from a figure representing an arbitrary split of the difference between net original cost and net reproduction cost, to reproduction cost alone. In the author's company, because of the large extent of property added during the past decade, the net reproduction cost represents about 160 per cent of the net original cost. In the company's rate cases, the commission has established a fair value between 125 and 130 per cent of net original cost. Apparently, the Supreme Court of Illinois, in its Illinois Bell decision (*3*), had in mind that fair value should approximate reproduction cost, because the court said, ". . . arrived at after full and proper consideration of reproduction cost." In a later point in the decision, however, reference is made to original cost of construction as one of the matters to be considered.

In the Hope Natural Gas Co. case (*2*) and in the Bluefield Water Works case (*4*), the US Supreme Court said, ". . . the return to the equity owner should be commensurate with returns on investments in other enterprises having corresponding risks." Under the laws of practically every state, a privately owned utility is entitled to a reasonable return on its net investment or on any other rate base that may be established in accordance with applicable law, if it can obtain such earnings under reasonable and nondiscriminatory rates. This, of course, presumes that business conditions are such that the utility can attain the established return. Probably, in no other field are conditions similar to those in utilities, and, therefore, to be some-

what liberal about the court's statement, comparisons of utility returns should be made with other utility returns. It is not certain, however, that this is what the court meant.

Depreciation

When corporate indentures are written, somewhere at the beginning there is a definition of terms, and whenever one of these terms is used, it means exactly and only what the definition says it means. It is perhaps unfortunate that there are no equally explicit definitions of some of the terms frequently used in the utility field. "Depreciation" is one example of an ambiguous term. Does it mean setting up a fund that will return the original investment, or a fund that will replace the property worn out or exhausted in the course of rendering service? In practice, the policy followed by the Illinois Commerce Commission is the first interpretation. The officials of the author's company agree with the latter interpretation, because it imposes upon the current users of a service the cost of the property "consumed" in rendering the service.

This view is borne out by an order of the Indiana Public Service Commission in connection with the Indiana Telephone Corp. (*5*), as follows:

> Depreciation is as much a cost of doing business as wages and salaries and other obvious operating expenses; depreciation is the cost of the plant or property consumed from day to day in the production of services sold by a utility.

A contrary view was expressed by a member of the Wisconsin Public Service Commission in an article that appeared in the JOURNAL (*6*):

> The proper function of depreciation is the assignment to each year of the life of a property unit a proportionate part of its costs, so that at the end of the period, the full net cost of the unit will have been recovered.

Perhaps in the not too distant future the courts will define depreciation. In filing for a new rate schedule, the amount of depreciation to be claimed in the operating expenses is a matter of some importance.

What has just been said applies to privately owned water utilities. With publicly owned utilities, the intent of depreciation is not clear. In comparable utilities, depreciation should not differ merely because the utilities are publicly or privately operated, and, consequently, no difference should exist in accounting for the annual depreciation expenses. In fact, depreciation is a method of accounting for the consumption of capital invested in a plant. It does not require a cash outlay, for it it is the charging off to annual operations of a pro rata part of the cost of the plant.

Taxes

Earlier it was pointed out that some public service commissions will not include working capital in the rate base, asserting that those funds the company has collected from its customers for the payment of taxes should provide cash that can be used as working capital. This seems to be a business philosophy of "robbing Peter to pay Paul." Everyone knows that taxes must be paid when due. Therefore, funds collected to pay taxes should be used for taxes and not for operating expenses. If tax money were a company's only working capital, and if all taxes had to be paid out at a particular date, the company would, immediately after that date, have no working capital. Probably, such a situation will

never occur, but, stated bluntly, excluding working capital from the rate base seems to be a device for depriving the utility of income. Happily, this condition does not prevail in Illinois.

Taxes usually represent the principal difference in the annual expenses of publicly and privately owned utilities. A privately owned utility is normally subject to ad valorem and income taxes and, in some cases, franchise taxes. A publicly owned utility is usually exempt from income taxes and franchise taxes, and may be exempt from part or all of the usual ad valorem taxes, or, in lieu of this, exempt from payments to the levying units. It should be noted here that the Indiana gross income tax law has been applied to municipal utilities: *Department of Treasury* v. *City of Evansville,* 1945.

Rate Case Procedure

When the management of a privately owned utility finds that the company's income is less than the amount allowed by the regulatory policy of the state, it prepares and files new rate schedules that will result in the allowable income. Management will become aware of the regulatory lag in preparing the rate schedule, but no one has found a way to avoid the lag. In the rate cases in which the author's company has participated, income has always been less than the amount stated in the commission's order as a fair and reasonable return.

Required Data

After filing a new rate schedule, the utility can anticipate some opposition to the proposed rate increase; in any event, the commission will not grant an increase unless the utility proves that it is entitled to one. It must, therefore, prepare the data that it will require to substantiate its claims wholly or in part. The required data should consist of: [1] a detailed, actual income statement for the test period and [2] a *pro forma* income statement showing the anticipated income on the basis of the proposed rate. Needed to prepare the latter statement is a customer analysis for the test period, which usually covers the past year of operation. A customer analysis is simply a grouping of customers on the basis of the quantity of water they consume. It is required so that the various unit blocks in the proposed rate schedule can be applied to determine the operating revenues to be expected from each group.

For the determination of fair value, various data are required. *Original cost figures* of the physical property must be presented, but because the plant account is stated on this basis, there is no problem here. A figure of the *amount of materials and supplies* that the company is normally required to have on hand must be shown. An estimate of the *working capital* must be made. For a company that renders its bills monthly, the commission will normally allow 6 weeks of operating expenses or, possibly, one-eighth of the annual operating expenses, excluding depreciation and taxes.

Also required are figures of the *present replacement value* or reproduction cost new of the physical property. This means a detailed inventory of the property, to which there will be applied current figures showing the cost of materials and labor. Figures of accrued depreciation are determined primarily from an age-life or an observed basis. Because much of the property

of a water utility is nonobservable, accrued depreciation is sometimes worked out on the basis of observed depreciation, where this is possible, and on an age-life basis for nonobservable property, with the life of the latter based on a schedule that is the result of experience. A number of valuation reports have been made on the property of the author's company, and, in some instances, a number of openings were made in pipes so that the engineers could observe the inside and make certain that the depreciation was not in excess of the schedules they were using.

Lastly, some evidence is needed of the proper *rate of return*. In Illinois the concept of fair value of property can develop because of the consideration given to the elements of value previously mentioned. Needed now is a rate of return that can be applied to fair value to determine fair earnings. For testimony on this problem, an expert in the field is required, one who usually ranks as a security analyst, an economist, an investment banker, and, sometimes, a commercial banker. In practice, as long as 3–6 months may be necessary to collect the data needed for a rate case.

When all the data have been prepared, the procedure in Illinois specifies that the utility file with the Illinois Commerce Commission the proposed new rate schedules, which must be exactly in the required form. Practically simultaneously, the utility must post the new schedules in its offices and advertise them in a local newspaper of general circulation.

Rate Case Hearing

When the case is set for a hearing by the commission, it is necessary for an official of the utility to testify that the rates were filed with the commission and posted in the utility's offices. The official must also offer certified statements (proof of publication) that the schedules were advertised in the newspapers on specified dates.

Rate case hearings are normally held before an examiner, who sometimes has an assistant or an associate examiner. These men are members of the commission's staff and are experienced in rate case procedure. The hearings follow general court procedure, though they are somewhat less formal. Stenographic reports of all testimony are taken; transcripts are readily available to all interested parties. At the hearings, witnesses for the utility usually include the counselors representing the utility. Witnesses for the community usually include the city attorney, special counsel, and, sometimes, the mayor or other city officials. All witnesses must be sworn.

Case Presentation

The utility presents its side of the case first. Witnesses for the utility, chosen to present the different parts of the utility's case, give direct testimony by answering the questions of the counsel for the utility. Whenever revenue figures, value figures, and similar evidence are brought into the case, they are numerically identified for exhibit, as required by the commission. Exhibits for the utility are called "respondent's exhibit," those for the community, "objector's exhibit."

When the utility's witness has completed his testimony, he is subject to cross-examination by the objector, but this is seldom undertaken at this time. The objectors usually ask for a recess in order to study the utility's testimony

and exhibits. The duration of the recess period set by the commission will very likely be a compromise between the periods requested by the objector and the utility.

When the hearing reconvenes, the objectors cross-examine, in whatever order they prefer, the witnesses who have already testified. To do a thorough cross-examination, an attorney must be experienced in rate making, but the average city attorney does not have the necessary qualifications, and there are not many lawyers in private practice who have. Big cities can afford the services of experienced counsel to oppose rate cases, and though small communities cannot, a witness for the utility should not anticipate having an easy time during cross-examinations.

When the objectors have finished their cross-examination, the utility may recall its witnesses for *redirect* testimony, either to present additional matters or to clarify information already presented. The objectors, of course, have the right to cross-examine the witnesses on the additional information. At this point, the opposition can present its case if it so desires, but this happens only occasionally. One reason for the delay is the expense of presenting direct testimony and supporting exhibits. Most city councils, therefore, seem to prefer to make their case by attempting to break down the testimony of the utility's witnesses. If, however, the opposition does offer witnesses and exhibits, the utility, of course, has the right of cross-examination.

When both the utility and opposition have completed their testimony and examination, the counsel for either side can ask for "oral argument" before the full commission. Argument so presented is supposed to be confined to the points developed in the testimony, but the counsel may use this opportunity to introduce some views of its own. When the oral argument is completed, the case is marked "heard and taken." Thereafter, the commission, with the aid of the staff, will study the arguments and testimony and hand down its order, which summarizes the evidence, makes its findings, and denies or establishes a new rate. On the basis of the commission's calculations, the new rate defines the income for the utility. Illinois law requires that the commission hand down an order within 11 months from the date of the original filing of new rate schedules. If the commission fails to do this, the rates as originally filed become effective.

Rehearing

After any first order of the commission, either side can petition for a rehearing. According to Illinois law, the commission must act on an application for rehearing within 30 days after the order is handed down, and it must either grant or deny the application within 20 days after it has been filed. Following a rehearing or after its denial, either party may appeal to the courts. Such an appeal would first be heard in the circuit court and could go from there to the Illinois Supreme Court. The Illinois Bell Telephone Co. case (*3*), referred to earlier, is an example of a case that was appealed through the state supreme court.

Conclusion

A rate case may result in many drawn-out proceedings. It is difficult, therefore, to discuss briefly the different situations that might occur, for there is involved not only the proceeding be-

fore the commission but also the appeals to the courts. Three articles (*6–8*), published in the JOURNAL in 1957, help to clarify the different problems involved in the determination of water utility rates.

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Municipally Owned Utilities—*S. T. Anderson*

A paper presented by S. T. Anderson, formerly Utilities Director, Dept. of Water, Light & Power, Springfield, Ill.

THERE is always a difference of opinion about the proper procedure for setting up water rates. It is doubtful whether any two experts can agree on a method to be used or on the factors that should be taken into account.

There must be a difference in rates for municipally owned and privately owned water utilities, because the former is not selling water but a service. The purpose of the rates is to pay for the cost of this service, and the duty of the management of a municipally owned utility is to furnish the service—providing an adequate supply of potable water—at the lowest possible cost. This means that with municipal ownership, instead of paying dividends to stockholders, a kind of dividend is paid monthly to the consumer in the form of low-cost water.

A municipally owned utility should not be operated for profit, only to have this profit diverted to other departments of the city or village, but it should, through the water department, pay its share to the city. The fairest method of doing this is for the water department to pay to the city an amount equal to the taxes that would be paid by a privately owned utility, and for the city to pay for the service it gets from the water department. Money should not be taken from the water department and used by the city to reduce taxes.

Rate Establishment

In establishing a rate for a municipally owned utility, many factors should be considered, including peak loads, demand, and load factors that affect the cost of operation of a water system. Water supplied during peak consumption periods costs more than that supplied during average periods, because additional plant facilities are needed, especially those used for pumping and distribution. Demand is an important consideration, especially when there is a seasonal use of water, such as for air conditioning. The customer should pay a minimum bill of

not less than one-fourth of the maximum bill for water used during the summer months, but in Springfield, Ill., there have been customers who paid a minimum bill of $0.60 in the winter and a maximum bill of $100 in the summer. The system of demand charge, however, has resulted in very few complaints.

A block rate should more than cover the cost of supplying water to the biggest consumer in the block. The overall rates should be high enough so that income is sufficient to pay for maintenance, operation, and interest and principal on outstanding bonds or on any new bond issues that are anticipated to pay for future capital additions. Studies of future demands should project 5–10 years into the future; the net income should be sufficient to provide for these future costs.

Required Income

Before issuing revenue bonds for any new construction, the water department should have a net income of 20 per cent more than the sum of the following: operating and maintenance costs; interest on previous and proposed bonds; a fixed sum each year for a reserve that would eventually cover the maximum principal and interest on the outstanding and future bonds for a 1-year period; and a depreciation account of some fixed annual amount, depending upon the size of the utility. The amount of money needed for expansions of the distribution system depends on what policy is followed in extending water mains into new areas. It is recommended that the utility pay the difference between the cost of the necessary 6-in. main in the new area and the size main that would be needed to supply water to areas farther away.

About 65 per cent of the cost of water is chargeable to fire protection and 35 per cent to domestic or commercial supply. Studies should be made of the possibility of reducing costs by using modern equipment where it can do a more efficient job than laborers can.

Rate Adjustments

Rates for consumers outside a city should be higher than for those inside, because, over the years, city residents have paid for the present plant, and because, in most instances, outside areas are at the end of the distribution system, making it necessary to pump water a greater distance. Special rates should be established for the use of sprinkler systems and privately owned fire hydrants. Higher rates on water used for construction should also be considered. And if a system is to operate efficiently, these uses must be strictly metered. A minimum rate, then, should reflect the cost of all services, including metering, billing, posting, and collection.

New-Rate Requests

When a privately owned utility wants to raise its rates, it must have the approval of the commerce commission. Rate increases for a municipally owned utility must be approved by the local governing body, whose elected officials are reluctant to increase rates for fear of adverse public opinion that might affect their campaigns for re-election. Therefore, the management of a municipally owned utility not only must collect data to prove to the governing body that increased rates are justified, but also must convince the public that the proposed rates are reasonable and that extensions are necessary.

Springfield, Ill., is only one example of a city whose water rates should have been increased at least 15 years ago, but it was impossible to convince the members of the governing council that this increase was necessary. The present council, however, has agreed to adjust the rates by increasing the minimum from $0.50 to $1 and by eliminating the two lowest categories in the step rate. Springfield's service costs on minimum bills are $0.96 per month per customer, for meter reading, billing, collecting, and posting. The cost of supplying water to the consumer, which includes the development of sources of supply, filter treatment, high- and low-service pumping, and distribution, is approximately $0.085 per 100 cu ft.

Working Capital

An important consideration for the establishment of rates is the working capital needed so that all bills can be discounted and payments made on time. Therefore, the utility's accounting department plays a vital role in keeping the plant operating in an orderly and efficient manner. Financial reports must be compared from month to month and from year to year, for, although management sets up an annual budget, expenses may fluctuate for any number of reasons, even because of extremes in weather. In order to maintain the working capital needed, some items may have to be eliminated from the budget.

Conclusion

A municipally owned utility should not be under the control of the commerce commission. If the operation of a utility is to reflect the needs of the consumer, water rates should be regulated by local government.

Chapter 7—Periodic Testing of Meters

AWWA Meter Manual

A manual on water meter selection, installation, testing, and maintenance has been prepared by AWWA Committee 8610—Meters. The document is being published in installments (June, p. 790; July, p. 913), and will afterwards be made available as a separate volume.

ALTHOUGH it has taken a great many years to obtain general acceptance of the use of water meters as the most equitable basis for charging for water service, full benefits from metering are not obtained unless a definite program of meter maintenance is carried out.

Purpose of Testing

A water meter, like any other mechanical device, is subject to wear and, over a period of time, loses its peak efficiency. How long water meters retain their overall accuracy depends largely on the quality of water being measured. There are several other factors, however, that cause excessive wear or inaccurate registration. Obviously, although the only way to determine whether any specific meter is operating efficiently is to test it, the problem of establishing a meter maintenance program is how to determine the frequency for testing every meter in service. From an individual customer's viewpoint, meters should be tested to protect him against meter inaccuracy that could result in overcharges. This, of course, is also of concern to utility management. Experience shows, however, that the greater concern of a water utility should be the revenue loss that results from underregistration of meters.

The economic advantage of meter maintenance programs has been recorded in many articles, but most of them have invariably covered concentrated efforts to rehabilitate meters after a long period of nonmaintenance and are of little value in answering the question of how often meters should be tested under a program of meter testing on a sustained, continuous basis. Unfortunately, there can be no single answer, as the economic result depends on such factors as the rates charged for water, the effect of waters of different quality on meters, and the cost of removal, testing, repairing, and installation of meters. A reasonably proper economic balance should be attained. If meters are not adequately maintained, loss of revenue to the utility results. Conversely, if the cost of a program of meter maintenance is more than the loss of revenue that would occur if the meters were not tested, the overall result is economic waste and the utility's customers are required to pay the unnecessary expense.

Test Frequency

Although many state regulatory commissions have adopted regulations concerning frequency of meter tests, it should be noted that any arbitrary time interval applied to several localities,

each with its own local conditions, cannot be economically correct for all. Table 7.1, compiled in 1954, is a listing of these regulations. It must be recognized, however, that the very existence of such regulations has often caused meters to be better maintained than without such regulations. It is inexplicable, but true, that meter maintenance in too many instances is considered of little importance, as something which is done only when other types of work that cannot be as readily deferred are out of the way. Only when meters are truly recognized as the only means by which revenue is obtained to operate the water system will the necessary time and study be given to the question of how frequently it is necessary to test meters for most efficient and economic results.

What are some of the things that must be known in order to establish time or registration intervals between tests? One, of course, with a fully metered system, is that percentage of water delivered to the distribution system which is registered by customers' meters. This is known as the "metered ratio." The expression, "percentage accounted for," is not used here, as there are so many methods and bases for estimates of unmetered uses that comparisons of water accounted for are often meaningless. If a low percentage of total water delivered to the distribution system in a year, such as 60–70 per cent, is recorded by all customers' meters, this is indicative of inefficiency, and may be the result of underregistration of meters, undue leakage in mains and

TABLE 7.1

State Public Service Commission Regulations for Periodic Testing of Water Meters

State	Effective Year	Rule No.	Interval Between Tests—*years*								Registration Between Tests—1,000 *cu ft*				
			Meter Size—*in.*								Meter Size—*in.*				
			⅝	¾	1	1½	2	3	4	6 or Larger	⅝	¾	1	1½	2
Alabama	1936	60	10	8	6	4	4	4	4	4	100	150	300		
Arkansas	1937	58	10	8	6	4	4	4	4	4	100	150	300		
Colorado*	1949	21	5	5	5	4	4	3	2	1					
Connecticut	1935	48	5	5	5	4	4	3	2	1	200	500	1,000	2,500	4,000
Delaware	1952	17	8	8	5	5	2	2	2	2					
Illinois	1915	12	10	8	6	4	4	4	4	4	100	150	300		
Indiana	1942	14	10	8	6	4	4	4	4	4	100	150	300		
Kentucky	1935	67	5	5	5	4	4	2	1	1					
Maryland	1942	17	5	5	3	3	1	1	1	1					
Missouri	1953	42	10	8	6	4	4	4	4	4	200	300	400		
New Jersey	1917	X1	10	8	6	4	4	4	4	4	750§	1,000§	2,000§		
New Mexico†		None	10	8	6	4	4	4	4	4	200	300	400		
New York	1932	Schedule B	5	5	5	4	4	3	2	1	750§	1,000§	2,000§	3,000§	7,000§
North Carolina‡	1952	32				4	4	3	2	1					
Oklahoma	1943	15	—‖												
Oregon	1914	30	3	3	3	3	3	3	3	3					
Pennsylvania	1946	7	10	8	6	4	4	4	4	4	100	150	300		
Utah	1937	Sec. II-D	—‖												
Washington	1944	W-12	5	5	5	4	4	3	2	1					
West Virginia	1948	38	7	7	5	4	4	2	1	1					
Wisconsin	1949	11	—‖												

* Determined by local conditions; periods shown are average.
† No official ruling; periods shown are considered reasonable.
‡ Applies only to compound, velocity, and fireline meters.
§ Registration is in units of 1,000 gal.
‖ As often as necessary to comply with commission accuracy standards.

services, or a combination of both. Even when a water system is only partially metered, a marked variation in the percentage from year to year should be investigated.

Practically no study that is made, however, can tell how much of the loss is due to underregistration of meters. This amount can only be determined by testing. Some indication can be obtained by installing new meters in series with old meters in service and, by selective sampling, projecting the probable loss due to underregistration for meters that have been in service for certain periods of years. If meters of different makes and various models are used, such sampling can become quite complex and the results may be of dubious value. There is, however, a very distinct value in such in-service comparisons—that is, to show conclusively how much underregistration and resultant loss in revenue occurs if meters are not maintained in good operating condition.

Program Coordination

To start a program of periodic testing, it is necessary to adopt an arbitrary period in which to complete the work, and it is desirable to select a period of years that coincides with the best estimate of the frequency with which meters should be tested. In this way, the work is leveled out, and the next time meters are tested nearly the same number are due for test each year. If, for example, a utility with 10,000 meters in service sets up a program for testing meters on a 10-year cycle, it has to remove approximately 900 meters each year. This is less than 10 per cent of the number in service, as there are always meters that will not remain in service for the full period and will be removed for other reasons. In order to provide for even work flow, both in the changing of meters and shop work, it is preferable to have the number of orders required prepared on a daily basis. Assuming 250 working days in a year, in order to complete the periodic testing of 900 meters per year the testing of roughly four meters each day would be necessary in addition to other required work. If, therefore, four orders are written each day, progress of the program may be reviewed at any time by a count of the number of uncompleted orders for changing meters for periodic test and a check to see if the shop work is getting done without building up a backlog of meters. Although the testing of 10,000 meters may seem a staggering job, it is surprising, once the work is started on a systematic basis, how the additional work is absorbed and soon becomes routine. Obviously, as actual test results of meters removed from service are accumulated, experience is obtained as to the length of time it takes, on the average, for meters to lose sensitivity on low flows and the length of time meters are permitted to remain in service can be adjusted on the basis of known results.

It is generally considered advisable to provide for more frequent tests of large meters, on the logical premise that an error in their registration affects revenue to a much greater extent. Furthermore, current and compound meters may overregister to a much greater degree than positive-displacement meters. If a sufficient number of 3-in. or larger meters are installed, the repair and testing of these larger meters may be delegated to one particular person or crew and divorced from the normal procedures

set up for handling maintenance of small meters.

Probably the best advice which can be given on this involved and difficult problem is to be alert to, and study all phases of, the subject, as there is no substitute for experience in arriving at the best answer. It should be constantly borne in mind, however, that, although a metered system is the best basis known for equitably spreading the cost of water service, serious inequities and injustice can be introduced unless all meters are maintained at a high, uniform level of efficiency and unless every reasonable effort is made to see that inequities do not occur.

Chapter 8—Test Procedures and Equipment

THERE is probably no phase of water works operation which has been handled in so many different ways as that of testing water meters. Unquestionably, this is because no complete testing standards had been established prior to 1957 and individuals were required to formulate their own opinions of how testing should be done. Until the adoption of AWWA C705, the only meter accuracy requirements available in the past were those contained in AWWA purchase standards for cold-water meters. They are designed to insure that *new* meters meet certain accuracy requirements. These accuracy requirements are not specific enough for use when meters are tested for other reasons. For example, when meters are purchased, the buyer wants to be assured that the meters he receives are within definite limits of accuracy on any and all rates of flow within the operating range of the meter. The accuracy requirements of AWWA standards for purchase are so worded as to constitute a warranty. Obviously, no one can be expected to test meters on every conceivable rate of flow, and a sufficient number of specific rates must be selected to determine with reasoned judgment that a meter is within definitive accuracy limits on all flow rates within design capacity. Basically, the decision of the number of tests, test rates, and quantities to be used in testing new meters is left to the manufacturer, with the exception that definite minimum flow rates are established. The absence of definite test standards for normal water utility operation has been the major reason for the wide variance in testing procedures being used. It may well be asked what harm there is in this situation. In answer it is necessary to look into the reasons for testing water meters and what use is made of the results obtained.

First on any list of reasons for meter tests would be to insure that the cost of water service is equitably distributed among all customers. Unless all meters register within defined close limits of accuracy, equitable cost distribution does not occur. For this reason, regulatory commissions have established definitive meter accuracy requirements and the frequency of tests of water meters. A review of such commission requirements, however, shows the confusion existing on this subject.

Secondly, loss of revenue to the water utility may occur if meters are not maintained at a reasonable level of efficiency. Unfortunately, positive-displacement meters, which are the type most commonly used, may seriously underregister for long periods without complete stoppage. It is necessary to test meters periodically to minimize this loss of revenue. The accuracy of current meters is also subject to change while they are in service, and they may either under- or overregister. Unfortunately, the period of time for which water meters retain overall accuracy is variable and depends mainly on the characteristics and quality of water being measured. The rates charged for water service

also have a distinct bearing on how frequently meters should be tested. It is difficult to determine the economic balance between the cost of more frequent testing and potential loss in revenue caused by meter underregistration. Proper meter tests are necessary, however, in any such evaluation. Unless meter testing procedures reflect overall operational ability and the same procedures are followed consistently, changes in meter accuracy after periods of service cannot be determined.

Finally, it would be well if everyone spoke the same language. There are annually many talks on meter department operation and test procedures, but there can be no common ground for comparison unless the results are based on one method or standard.

Elements of a Meter Test

The three basic elements of a meter test are:

1. The number of different rates of flow over the operating range of a meter required to determine overall meter efficiency.
2. The quantities of water necessary at the various test rates to provide reasonable determination of meter registration.
3. Accuracy limits which meters must meet on the different rates to be acceptable for use.

Test Rates

Three rates of flow are necessary properly to test water meters of positive-displacement and current types—maximum, intermediate, and minimum. At least one, and preferably more, additional tests are necessary within the changeover range of flows of compound meters to determine overall operational efficiency and accuracy of registration.

The maximum rate of flow is often selected as the rated meter capacity. Registration curves of water meters show that positive-displacement and current meters in good operating condition follow a general pattern of registration. Above the very low flows which the meter will not register, there is an intermediate point of maximum registration. Above and below this point, lower registration is obtained. The maximum point of registration depends on meter design but is usually about 10 per cent of rated meter capacity. At rates above that of maximum registration, the accuracy curve is fairly flat, so that there is little difference in accuracy over a wide range of flows. Selection of the maximum rate of flow at which meters are tested is not therefore of major importance. Maximum-rate test flows of approximately three-fourths of rated capacity are practical, particularly because meters are seldom operated at rated capacity. This lower test rate is advantageous with multiple testing of small meters and is possible with pressures and testing equipment usually available.

The intermediate rate of flow should be at or near the high point of registration to insure against overregistration of the meter on any rate of flow, and should therefore be approximately 10 per cent of rated capacity.

The minimum-rate-of-flow test does more to disclose operational ability and proficiency of meter repair than either the maximum or intermediate flow tests. All three, however, are necessary to evaluate overall meter accuracy.

Test rates of flows should be measured in actual units, such as gallons per minute. Rates based on size of

orifice are not reliable because of possible enlargement of the orifice from wear or changes in pressure during tests.

Test Quantities

The quantities of water necessary to reduce testing errors to an acceptable minimum depend on two factors: [1] accuracy of test equipment, and [2] visual ability. Commercial calibrated tanks and scales provide overall equipment error of less than 0.3 per cent. Unless checked periodically, however, such equipment's accuracy may be radically changed, and it is recommended that a definite schedule of proving test equipment be followed, preferably by an official sealer of weights and measures.

Meter registers of two types are available—those with a center sweep test hand and those with the test index of the same small size as other indexes of meter dials of round reading registers. Obviously, registers with a center sweep hand provide for better visual reading and smaller test errors than do the smaller indexes. The difficulty of visual error of the smaller

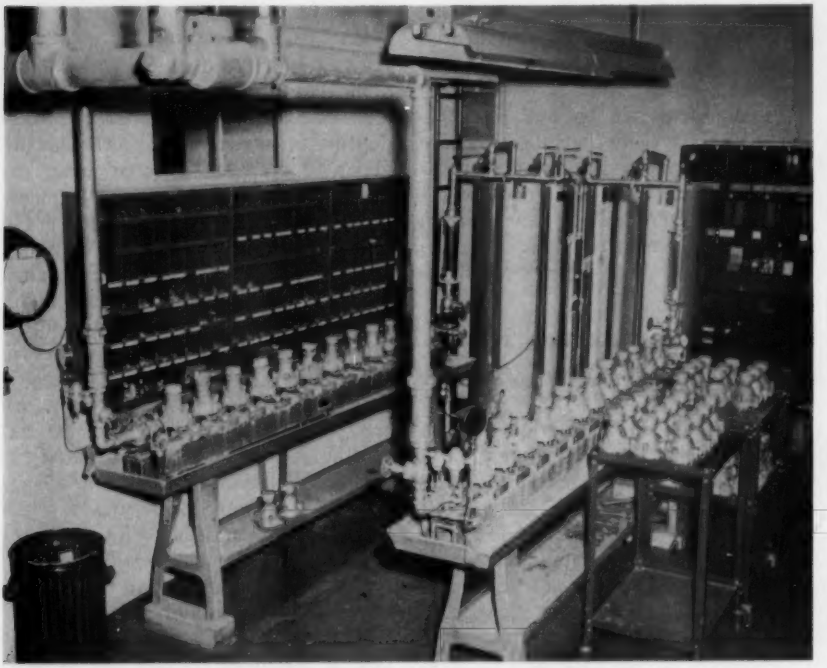

Fig. 8.1. Test Benches for ¾-in. Meters

Each bench can test twelve ⅝ × ¾-in. meters, and has a rate-of-flow indicator; an electrically actuated shutoff valve; and a 1-cu ft and a 10-cu ft calibrated tank. The benches have hydraulically operated clamping mechanisms.

indexes can be minimized by using greater test quantities of water. This, however, increases testing time and the size of tanks and scales. Another expedient that reduces the time of testing without sacrificing accuracy is the test register. One type of test register has a center sweep hand, but its disadvantage is that the regular meter register is not used and the test does not therefore include the entire meter assembly. Another type of test register consists of a bonnet which fits over the regular meter register (in place of the register box) and an enlarged test dial. A sweep hand is snapped over the small test hand of the meter register through an opening in the bonnet. It is preferable, even with center sweep test hand registers, to use quantities of water which provide for complete revolutions of the test hand. This eliminates possible errors due to uneven stamping of meter dials and eccentricity of the test dial.

Accuracy Limits

Obviously, accuracy limits are established to insure that water meters record as accurately as commercially feasible. Meters have an inherent variation of 2–3 per cent in registration over the entire range of flows, except low flows just above those that the meter will not register.

The water meter test requirements in Table 8.1 have been prepared by the AWWA Meter Committee to establish a standard for testing meters. These procedures were approved by the Association's Board of Directors in January 1957 and have been published as AWWA C705. It will be noticed that recognition is given to the fact that it is often not economically feasible to repair older meters to pass the accuracy requirements for new meters on the minimum rate. For this reason, separate accuracy limits are shown for new and repaired meters on the minimum-flow test. The limits set for repaired meters are considered to represent those which require good meter shop procedures to achieve. It is not considered that acceptable meter repair work is being accomplished if repaired meters will not register at least 80 per cent on this test.

Test Equipment

Equipment required to test a water meter may be very simple. Test procedure may consist only of installing the meter in a pipeline which has a control valve to regulate the flow and discharging the test water into a tank on a set of scales to weigh the water. Obviously, some means of determining the rate of flow is necessary in making a test in this manner, and a watch may be used for this purpose. Another means of determining rates of flow in testing meters, and one which has been used extensively in the past, is to discharge the test water through orifices of various sizes, each designed to deliver at a constant pressure a given rate of flow. Timing test rates with a watch, however, is not practical for routine testing work, and the possible error introduced in the use of orifices by wear and changes in pressure has been previously mentioned. The latter method is not recommended.

Where the number of meters to be tested warrants, more suitable test equipment is commercially available. Meters may be tested singly or in groups, and the equipment selected should be based on the work load. When reasonable judgment is exercised in selection of test equipment, the cost is quickly repaid and more

TABLE 8.1

Tests for Cold-Water Meters

Size *in.*	Maximum Rate				Intermediate Rate				Minimum Rate				
	Rate of Flow *gpm*	Test Quantity		Accuracy Limits* *per cent*	Rate of Flow *gpm*	Test Quantity		Accuracy Limits* *per cent*	Rate of Flow *gpm*	Test Quantity		Accuracy Limits *per cent*	
		gal	*cu ft*			*gal*	*cu ft*			*gal*	*cu ft*	New Meters	Repaired Meters†
Positive Displacement Meters													
$\frac{5}{8}$	15	100	10	98.5–101.5	2	10	1	98.5–101.5	$\frac{1}{4}$	10	1	95–101.5	90–101.5
$\frac{3}{4}$	25	100	10	98.5–101.5	3	10	1	98.5–101.5	$\frac{1}{2}$	10	1	95–101.5	90–101.5
1	40	100	10	98.5–101.5	4	10	1	98.5–101.5	$\frac{3}{4}$	10	1	95–101.5	90–101.5
$1\frac{1}{2}$	80	1,000	100	98.5–101.5	8	100	10	98.5–101.5	$1\frac{1}{2}$	100	10	95–101.5	90–101.5
2	120	1,000	100	98.5–101.5	15	100	10	98.5–101.5	2	100	10	95–101.5	90–101.5
3	250	1,000	100	98.5–101.5	20	100	10	98.5–101.5	4	100	10	95–101.5	90–101.5
4	350	1,000	100	98.5–101.5	40	100	10	98.5–101.5	7	100	10	95–101.5	90–101.5
6	700	1,000	100	98.5–101.5	60	100	10	98.5–101.5	12	100	10	95–101.5	90–101.5
Current Meters‡													
$1\frac{1}{2}$	80	1,000	100	97–103	15	100	10	97–103	7	100	10	95–103	90–103
2	120	1,000	100	97–103	20	100	10	97–103	10	100	10	95–103	90–103
3	250	1,000	100	97–103	30	100	10	97–103	15	100	10	95–103	90–103
4	400	10,000	1,000	97–103	50	1,000	100	97–103	20	1,000	100	95–103	90–103
6	1,000	10,000	1,000	97–103	100	1,000	100	97–103	30	1,000	100	95–103	90–103
8	1,600	10,000	1,000	97–103	200	10,000	1,000	97–103	50	1,000	100	95–103	90–103
10	2,500	10,000	1,000	97–103	300	10,000	1,000	97–103	75	1,000	100	95–103	90–103
12	4,000	10,000	1,000	97–103	400	10,000	1,000	97–103	100	1,000	100	95–103	90–103
16	7,000	10,000	1,000	97–103	600	10,000	1,000	97–103	150	1,000	100	95–103	90–103

TABLE 8.1 (*contd.*)

Size *in.*	Maximum Rate				Intermediate Rate				Minimum Rate				
	Rate of Flow *gpm*	Test Quantity		Accuracy Limits* *per cent*	Rate of Flow *gpm*	Test Quantity		Accuracy Limits* *per cent*	Rate of Flow *gpm*	Test Quantity		Accuracy Limits *per cent*	
		gal	*cu ft*			*gal*	*cu ft*			*gal*	*cu ft*	New Meters	Repaired Meters†
Compound Meters‡													
1½	80	1,000	100	97–103	15	100	10	97–103	¼	10	1	95–103	90–103
2	120	1,000	100	97–103	20	100	10	97–103	¼	10	1	95–103	90–103
3	250	1,000	100	97–103	30	100	10	97–103	½	10	1	95–103	90–103
4	350	10,000	1,000	97–103	50	1,000	100	97–103	¾	10	1	95–103	90–103
6	700	10,000	1,000	97–103	100	1,000	100	97–103	1½	100	10	95–103	90–103
8	1,200	10,000	1,000	97–103	200	10,000	1,000	97–103	2	100	10	95–103	90–103
10	1,600	10,000	1,000	97–103	300	10,000	1,000	97–103	4	100	10	95–103	90–103
12	2,400	10,000	1,000	97–103	400	10,000	1,000	97–103	7	100	10	95–103	90–103

* Accuracy limits recommended for repaired, as well as new, meters.

† Tabulated minimum-rate accuracy limits for repaired meters are those which can be achieved with most meters and good meter repair procedures. Any meter, regardless of age, which cannot be repaired to test 80 per cent or better on the minimum flow test should not be placed in service.

‡ If larger than 2 in., these meters should preferably be tested in the field by comparison with a test meter. Compound meters should also be tested at a rate within the "changeover" range of flows. As this range is variable, depending on make of meter and sizes of bypass (or small) meter unit, no one set of definitive rates can be established. Minimum required accuracy at any rate within such "changeover" range of flows is 85 per cent. The bypass (or small) meter unit of compound meters should also be tested at a rate as near as possible to the maximum test rate listed for disc meters of the same size (without causing the compounding valve to open). Accuracy limits on this test are 98.5–101.5 per cent. Specific rates cannot be readily tabulated for this test, as various makes of compound meters have different sizes of small meter units and are designed so that different rates of flow open the compounding valve.

accurate results usually obtained. Five requisites of good test equipment are:

1. A test bench in which meters may be quickly and securely held
2. An inlet valve
3. A quick-closing valve on bench discharge to regulate flow

Suitable test equipment for testing $\frac{5}{8}$, $\frac{3}{4}$, and 1-in. meters consists of the following:

1. A tank of 10-cu ft or 100-gal capacity, preferably calibrated for volumetric testing, or set on platform scales for weight determination

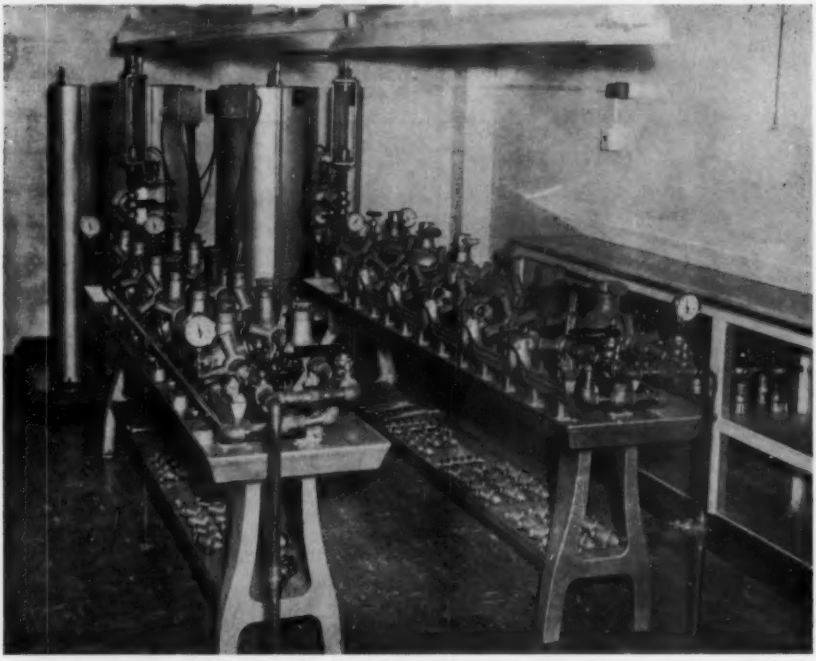

Fig. 8.2. Efficient Test Bench Arrangement

Shown are two test benches, each with a capacity of twelve meters. Automatic cutoff valves are clamped to the larger tanks.

4. A rate-of-flow indicator
5. One or more tanks, preferably calibrated for volumetric testing or a tank set on platform scales for testing by weight (Calibrated tanks must, of course, be installed in a plumb position to avoid inaccuracies of calibration).

2. A tank of 1-cu ft or 10-gal capacity, similarly equipped
3. A test bench provided with necessary fittings, including a control inlet valve, a quick-acting rate control valve on the discharge, and a rate-of-flow indicator. This bench may be of

single-meter capacity or designed for simultaneous testing of a number of meters (Fig. 8.1 and 8.2).

Similar equipment should be provided for testing meters larger than 1-in. size. An additional tank of 100 cu ft or 1,000 gal should be provided for testing larger meters. A rate-of-flow indicator of larger capacity is also essential. Test benches (Fig. 8.3) for 1½- and 2-in. meters are available and are recommended if sufficient testing of meters in these sizes is required. Piping should be provided for testing 3-in. and larger meters if such sizes are shop tested (Fig. 8.4). This is usually accomplished by making a piping arrangement with space for the longest meter and an assortment of filler pieces for inserting meters of shorter length (Fig. 8.5). This arrangement is frequently used for 1½- and 2-in. meters, instead of a special test bench, particularly when few meters of these sizes are in use.

Procedure

Although the following description covers the actual steps in testing a single ⅝-in. meter, the only differences for larger meters are the rates of flow and test quantities used. Test equipment is assumed to be that described in the preceding chapter:

1. Clamp the meter securely in the test bench. (Do not tighten more than necessary to make a watertight connection, as there is a possibility of distorting the meter housing.)
2. Remove the register box cover.
3. Open the discharge valve first; then open the inlet valve and run water to waste until the entrapped air is cleared. This also insures a full discharge line to the tank.
4. Shut off the discharge valve.
5. Check 100-gal or 10-cu ft tank discharge to insure that the tank is empty and then close the tank drain valve. (Tank discharge should be to an open drain so that any possible leakage of the tank drain valve can also be observed.)
6. Revolve the meter register to set the test hand at the zero mark. In so doing, revolve the register beyond the zero mark and then reverse its direction to bring the test dial hand forward to the mark. This takes up any possible backlash in the gearing.
7. Open the test bench discharge valve as rapidly as prudently possible to the desired rate for the maximum-flow test (15 gpm) and continue the flow at this rate until the meter test hand has made ten complete revolutions, stopping test at the starting

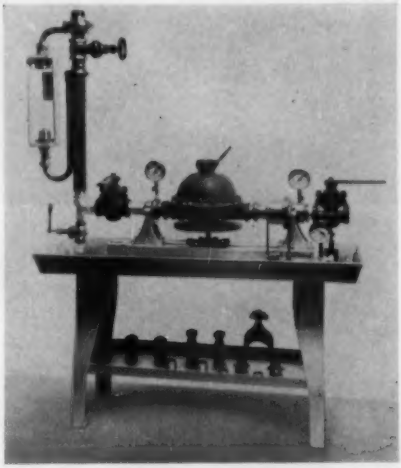

Fig. 8.3. Test Bench for 1½–2-in. Meters

This single-unit test bench is equipped with a double-range test rate indicator.

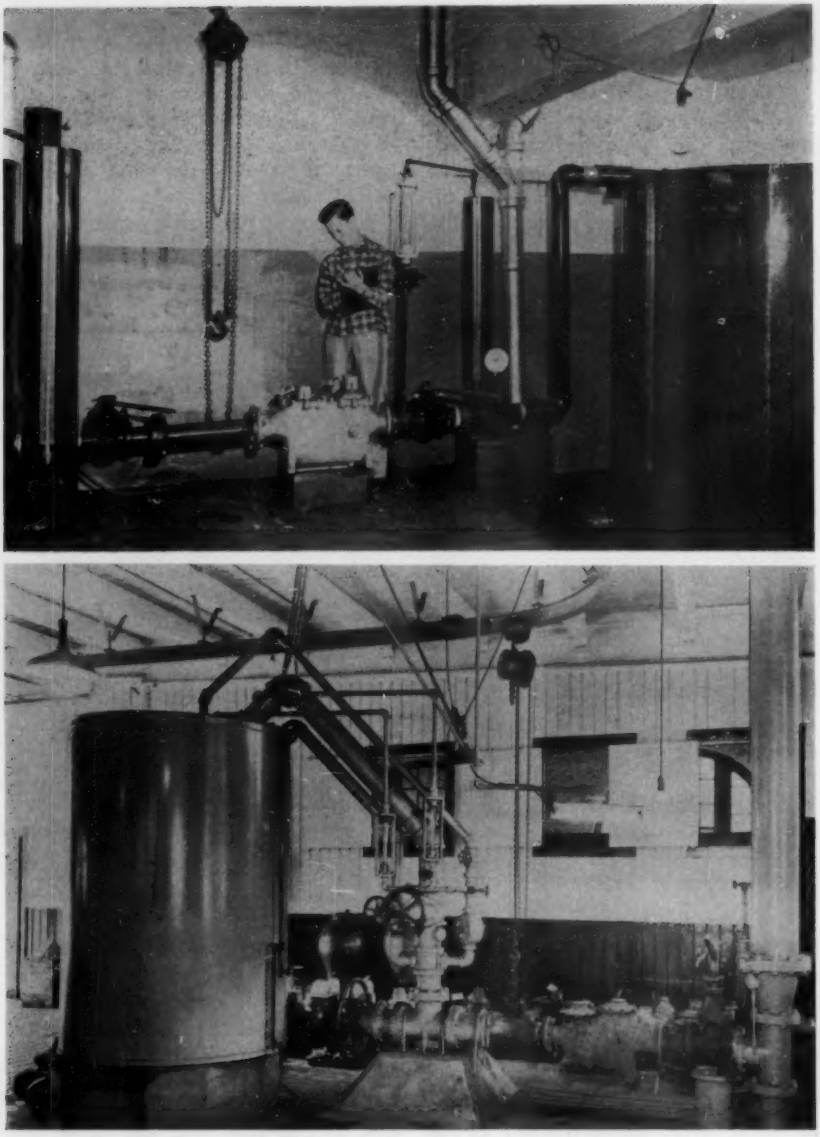

Fig. 8.4. Large Meter Test Racks and Piping Arrangements

In both of the test arrangements shown above, provision is made for variations in meter size by means of sliding pipe joints.

mark. Read meter accuracy from the scale of the calibrated tank (Fig. 8.6) or, if tank is not calibrated, by weighing water in tank.

8. Post the results of this test on the record form used.

9. If the meter being tested is a repaired meter and its accuracy does not fall within prescribed limits, refer to the change gear chart and replace change gears with a set that should cause the meter to register within required limits at this rate. Repeat the test as outlined. (Do not depend on the theoretical change in meter accuracy from changing gears. Always be sure that the meter tests correctly by rerunning the test after any change in gears is made.)

10. If a repaired meter is being tested and is found to register within limits on the maximum-flow test rate, repeat Steps 3–8, inclusive, for the intermediate (2 gpm) and minimum (¼ gpm) tests, discharging the test water into the 10-gal or 1-cu ft tank. The test quantity for these rates is only 10 gal or 1 cu ft and the meter register test hand completes only one full revolution.

11. If, however, the test is to determine the condition of a meter upon removal from service, it is desirable to rearrange the order of test flows. The preferable order in this event is the minimum-, intermediate-, and, finally, the maximum-flow test. If a meter that has been in service for some length of time is first tested on the high rate of flow there is a possibility of freeing the disc, thereby obtaining a false impression of the meter's condition on lower rates. Conversely, meters should be tested as soon as possible after removal from service to prevent drying out of deposits in the measuring chamber, as this condition tends to give an adverse impression of the meter's condition while it was in service.

12. After the three separate test runs are made, the meter has been fully tested and may be removed from the test bench after the inlet valve of the test bench has been closed and pressure has been released by a partial opening of the discharge valve.

13. Upon conclusion of final test, the meter should be drained, the register sealed, and dust caps placed on

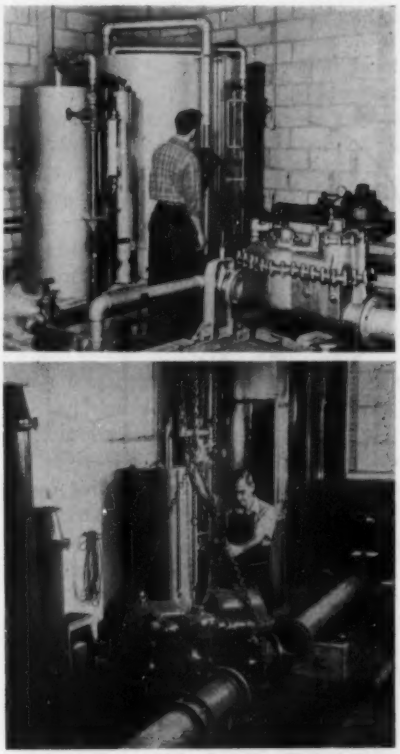

Fig. 8.5. Testing of Large Meters

The filler sections shown lined along the wall in the lower photograph are for adapting the test rack to various sizes of meters.

the meter spuds before the meters are put in storage.

Particular attention is called to the fact that the calibration of a tank is based on the rated capacity of the tank and if lesser quantities are used in testing as is sometimes done, the calibrated percentage errors are not valid. For example, a 10-gal tank may be used as a 1-gal tank by lowering the water level to the 9-gal mark and running water to the 10-gal mark. This is not recommended, but it is sometimes done to save testing time.

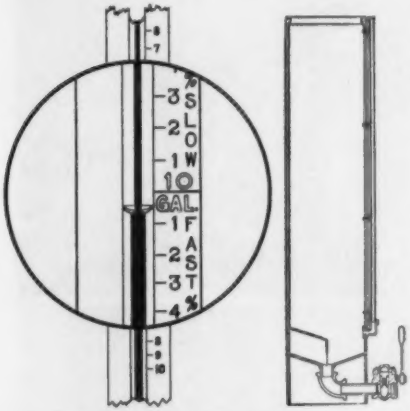

Fig. 8.6. Calibration Scale of Testing Tank

This scale gives the amount of over- or underregistration (in per cent).

Under such conditions, each 1 per cent error on the calibration strip becomes 10 per cent.

It should also be noted that a rate-of-flow indicator is affected by water temperature below the 1-gal rate. Most rate-of-flow indicators are calibrated for 70°F and viscosity changes due to temperature affect the reading.

Most rate-of-flow indicators come equipped with a pointer to indicate true rates at the minimum-flow points and should be used. A quart milk bottle and a watch are good calibrating instruments for the ¼- and ½-gal points. This check on accuracy of low flow calibration is required only when a marked change in water temperature of test water occurs, probably not more often than four times a year.

Multiple Meter Testing

Multiple testing of meters is identical to the testing of one meter, except for one important factor. In multiple meter testing, it is not possible to use the meter test dials for determining the quantity run, as each meter is operating at a slightly different speed. The test quantities are therefore discharged into the tanks and the flow stopped when the exact quantity has been delivered. Each meter's accuracy is determined from that meter's register instead of from the tank calibration of scales. It is very important that the arithmetic of the test be clearly understood when meters are tested in this manner. In the tests described for testing one ⅝-in. meter, only two quantities were used, 100 gal or 10 cu ft for the maximum flow test and 10 gal or 1 cu ft for the intermediate- and minimum-flow tests. One full revolution of the test hand of a ⅝-in. meter registers either 10 gal or 1 cu ft and the test hand circle is divided into ten equal parts. Therefore, on the maximum-flow test, when the test hand makes ten full revolutions, each subdivision of the test dial circle is a 1 per cent variation. On the intermediate- and minimum-flow test of 10 gal or 1 cu ft, the test hand makes only one revolution and each subdivision represents a 10 per cent error.

When ⅝-in. meters are tested in groups and the exact test quantity is

discharged into the tank, the percentage of error between divisions of the test dial is variable and depends on the quantity, being 1 per cent for 100 gal (or 10 cu ft) and 10 per cent for 10 gal (or 1 cu ft). Furthermore, it must be determined whether the meter is fast or slow. If, in group testing $\frac{5}{8}$-in. meters on a quantity of 100 gal, the test hand of one meter shows it has made ten full revolutions plus one additional mark (1 gal), the meter has registered 101 gal when only 100 gal was delivered and the meter is registering either 101 per cent or 1 per cent fast. Similarly, if the test hand of another meter has made ten revolutions minus two marks (2 gal) it registers only 98 gal when 100 gal is being delivered and is therefore registering 98 per cent of accuracy, or 2 per cent slow.

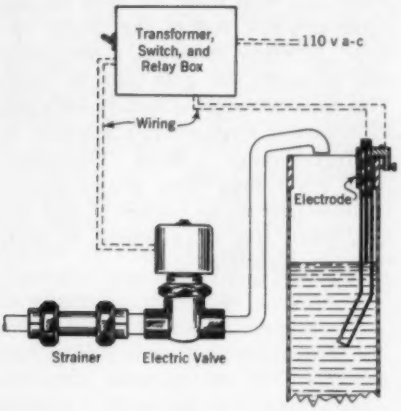

Fig. 8.7. Automatic Cutoff Valve

This device automatically stops the stream of test water when the testing tank is full. This feature makes it unnecessary for a man to stand watch to insure against overrun of the test.

When 10 gal (or 1 cu ft) are used in multiple testing, each division of the test dial circle represents 10 per cent error, and, if a meter register shows on the test that the test hand has only moved $\frac{9}{10}$ of the full circle, it is registering only 90 per cent. Unless meter registers with center sweep test hands or special test registers are used, it is necessary to interpolate between marks for closer-accuracy readings.

Although concern is often expressed over the time involved in testing meters on low rates of flow and large test quantities, testing meters in multiple reduces this factor on a unit basis. Furthermore, a relatively low-cost, automatic electric cutoff valve can be installed in the test bench unit. This makes it unnecessary to stand by to insure against overrun of the test. This attachment, shown in Fig. 8.7, consists of an electric valve with a strainer, a relay with transformer, one electrode for each tank, and the necessary wiring and switches. When the water in the tank rises to the test volume level (at which point the lower end of the electrode is secured) contact is made and forms a current path through the relay. This causes the relay contacts to open, which de-energizes the solenoid circuit of the electric valve and causes it to close and stop the flow.

Field Testing

Field testing of meters is usually confined to meters of larger than 2-in. size and is recommended for all sizes of current and compound types. Very few meter shops have tank facilities for the quantities of water needed to test these larger meters. Furthermore, the accuracy of current meters may be seriously affected by uneven

flow distribution caused by bends or other obstructions in close proximity to the meter inlet.

Field testing of meters is essentially the same as shop testing, except that, instead of using a tank to measure the test water, a comparison is made between the meter to be tested and one that has been previously calibrated. The two meters are connected in series and the test water is discharged to waste. As the calibrated meter is not 100 per cent accurate on all flows, it is necessary to adjust for its variation in accuracy at different rates of flow, in order to compute the accuracy of the meter under test.

One very important point to remember in field testing is that both meters must be full of water and under positive pressure. The control valve for regulating flow should therefore always be on the discharge side of the calibrated meter. Never use a valve on the inlet side of the meter being tested or one located between the two meters for controlling rates of flow, as inaccurate results may be obtained.

The discharge of test water often presents a problem in field testing of meters. An additional problem is to obtain a test meter with sufficient capacity to deliver the high rates of flow required for the maximum-flow test rate. It is often necessary to use a lower rate than those set forth for the maximum-flow test of the larger meters. In many instances, a maximum rate of only 500 gpm can be used. This rate, however, is usually sufficient to indicate a large meter's accuracy in the higher range of flows. Obviously, rates lower than those shown should be used only as an expedient and the established test rates should be used wherever possible.

Suggested Reduction Methods for the Determination of Nitrates

James M. Pappenhagen and Jerome J. Looker

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THE colorimetric determination of nitrates is a major problem in the analysis of water, sewage effluents, and industrial wastes. Published procedures show wide variations in accuracy, sensitivity, and freedom from interference. The phenol-2,4-disulfonic acid method and the aluminum reduction method (*1*), for example, do not always produce satisfactory results. They are time consuming and subject to serious interferences. Chloride and nitrite ions interfere in the phenol-2,4-disulfonic acid method; nitrite ions and ammonia interfere in the reduction method. Most of the other colorimetric nitrate methods have similar shortcomings and, like the two recent modifications of the brucine method (*2, 3*), require extreme care in technique before satisfactory results can be obtained.

Because there has been a widespread acceptance of the use of nessler reagent for the determination of ammonia, it was suggested that this reagent be studied for possible use in the determination of nitrates following reduction by the alkaline ferrous sulfate–silver sulfate technique (*4*). This article presents the results of such a study and compares these results to those obtained after using nessler reagent and two other reduction techniques: one utilizing a zinc-copper couple (*5*), and the other utilizing aluminum foil (*1*).

Apparatus and Reagents—General

A spectrophotometer * with matched 1-cm cells was used for absorbance measurements made at 410 mμ, with the instrument operated at a constant slit width of 0.04 mm. The steam distillation apparatus used with the alkaline ferrous sulfate–silver sulfate reduction consisted of a 1-liter, round-bottomed flask, a 500-ml kjeldahl flask, a 200-mm vertical spiral condenser, and appropriate clamps, rubber stoppers, and glass and rubber tubing. A straight glass adapter was placed over the tip of the condenser. Conventional glassware and distillation techniques were used with the other reduction procedures.

Ammonia-free water. Pass tap water through a mixed-bed demineralizer. This water is used for all aqueous solutions and dilutions.

Nessler reagent. Dissolve 100 g anhydrous mercuric iodide and 70 g anhydrous potassium iodide in a small quantity of water and add this mixture slowly, with stirring, to a cool

* Beckman Model DU; a product of Beckman Instruments, Inc., Fullerton, Calif.

solution of 160 g sodium hydroxide in 500 ml water. Dilute to 1 liter with water. Store in pyrex glassware and out of the sunlight (*1*).

Stock nitrate solution. Dissolve 0.7220 g dried, reagent grade potassium nitrate in water and dilute to 1 liter. Standard nitrate solutions are prepared as follows: Solution *A* (0.010 mg/ml nitrogen)—dilute 50.0 ml of the stock solution to 500 ml; Solution *B* (0.020 mg/ml nitrogen)—dilute 100.0 ml of the stock solution to 500 ml.

The special reagents used are described with each reduction technique. All chemicals used are of reagent grade.

Aluminum Foil Reduction

The aluminum foil reduction procedure, as described in *Standard Methods* (*1*), was studied for its accuracy in determining nitrates. The results obtained were so erratic and poor that it became impractical to make a statistical study. No satisfactory calibration curve was obtained. Because this procedure was so time consuming, no attempt was made to improve it.

Zinc-Copper Couple Reduction

It was believed that the use of the zinc-copper couple for reduction of nitrates might have several advantages over the aluminum reduction technique, one advantage being the shorter length of time needed for reduction.

Reagents (*5*)

Dilute sulfuric acid solution. Add 5.5 ml concentrated acid to 50 ml water and dilute to 100 ml.

Copper sulfate solution. Dissolve 3 g anhydrous material in water and dilute to 100 ml.

Sodium hydroxide solution. Dissolve 10 g of the material in water and dilute to 100 ml.

Sodium hexametaphosphate solution. Dissolve 5 g of the material in water and dilute to 100 ml.

Zinc-copper couple. Add sufficient granulated zinc to cover the bottom of a loosely stoppered 125-ml erlenmeyer flask. Wash with dilute sulfuric acid, drain, and then cover with the copper sulfate solution. As soon as the zinc is coated with a black deposit of copper, pour off the excess solution, and rinse the zinc several times with water.

Nessler reagent. Add a cold, saturated solution of mercuric chloride into a solution containing 35 g potassium iodide in 100 ml water until, after agitation, a slight red precipitate remains. Add 120 g sodium hydroxide to this solution, and dilute to about 1 liter. After the sodium hydroxide has dissolved, add a little more mercuric chloride solution to produce a red color, and complete the dilution to 1 liter.

Effect of Variables

The following procedure was used to study the effect of possible variable factors: To a nitrate sample was added 0.5 ml sodium hydroxide solution. Following evaporation to about half the volume, 0.5 ml concentrated hydrochloric acid was added to the cooled solution, which was then diluted to the original volume. A small portion of this acidified solution was used to rinse the couple and was then discarded. The remainder of this solution was poured on the couple, and reduction took place over a definite time at a fixed temperature. For direct nesslerization following reduction, an aliquot portion of the reduced solution was placed in a 50-ml volumetric flask, 1.5 ml sodium hydroxide solution added, and the solution diluted to volume and mixed well. After the precipitate had settled, an aliquot portion of this solution was placed in a volumetric flask, 1 ml

sodium hexametaphosphate solution added, nessler reagent added, and the solution diluted to volume. After 10 min, the absorbance was measured against a reference solution. For distillation of the ammonia following reduction, an aliquot portion of the reduced solution was placed in a distillation flask containing 200 ml water. Following addition of a definite volume of sodium hydroxide solution and application of heat, the distillate was collected in a volumetric flask and the ammonia content determined.

The published procedure (*5*) indicated that times of 2 hr at room temperature or 1 hr at 37°C were necessary for complete reduction. With the use of a temperature-controlled water bath, investigation showed that reduction could best be obtained by reducing for 30 min at 75°C. At higher temperatures, it would be necessary to cool the reduced solutions prior to the aliquot removal.

At all concentrations of reduced nitrate solutions, it was found that twice the volume of the British nessler reagent (*5*), compared to the recommended nessler reagent (*1*), was necessary for maximum color development. Although both reagents were stable and exhibited no change in composition over an 8-week period, the British reagent produced, for equivalent nitrogen values, absorbance values of approximately 90 per cent of those values obtained with the recommended reagent. For nitrogen values between 0.05 and 0.5 mg present in approximately 90 ml of distillate, 2.0 ml of the recommended reagent is considered satisfactory.

Although distillation prior to nesslerization might not be necessary for certain reduced nitrate samples, it was included in the recommended procedure to account for any turbidity or pollution that might be present. A study made of ammonia sample solutions following distillation indicated that quantitative recovery could be obtained if the pH of the solution in the distilling flask was 11 or higher. For nitrogen values between 0.05 and 0.5 mg, it was found necessary to distill two 50-ml portions or one 100-ml portion to recover all the ammonia. Although the recommended volume of 90–95 ml effectively lowers the sensitivity of the method, the advantage of such a technique is that for each sample only one reagent blank rather than two is needed.

A study of the reduction and distillation procedure applied to both ammonia and nitrate samples indicated that there was no quantitative reduction of nitrate; yet, there was a quantitative recovery of all ammonia produced. All nitrate samples produced a constant 90 per cent reduction to ammonia. A study showed that, with careful rinsing, each preparation of the zinc-copper couple could be used ten times.

Procedure

Apparatus. No special apparatus is necessary, although it may be desirable to use a temperature bath to control reduction. Steam out the entire distillation apparatus before use.

Preparation of calibration curve. Put 5.0-, 10.0-, 25.0-, 35.0-, and 50.0-ml portions of the standard nitrate solution, Solution *B*, into five beakers, and dilute to 100 ml with ammonia-free water. Proceed as described under "desired constituent." Plot milligrams of nitrate nitrogen against absorbancy, noting that only one-half the nitrogen is found in the distillate. Prepare a new calibration curve for each preparation of nessler reagent.

Sample. Obtain a representative liquid sample. If nitrites are present, determine their nitrogen equivalent on a separate portion of the sample, and subtract this value from the total nitrogen value found for the sample. Measure by volume an amount of sample containing from 0.1 to 1 mg nitrate nitrogen. Put the sample in a 150-ml beaker. If the volume is less than 100 ml, dilute to approximately 100 ml with ammonia-free water.

Desired constituent. Add 0.5 ml sodium hydroxide solution to the sample solution. Evaporate to about 40 ml and cool. Add 0.5 ml concentrated hydrochloric acid, and transfer the solution to a 50-ml volumetric flask. Rinse the beaker with several small portions of ammonia-free water. Add the rinsings to the flask, dilute to the mark, and mix the solution thoroughly.

Rinse the zinc-copper couple twice with small portions of the solution in the volumetric flask and drain thoroughly. Pour the remainder of the sample solution over the couple. Carry out the reduction for 30 min at 75°C.

Put 25.0 ml of the reduced solution into a 500-ml round-bottomed flask. Add approximately 150 ml water and 20 ml sodium hydroxide solution. Distill at the rate of 6–10 ml/min and collect approximately 90–95 ml of the distillate in a 100-ml volumetric flask. Mix the contents of the flask. Add 2.0 ml nessler reagent (*1*), dilute to the mark with ammonia-free water, and mix well.

After 10 min, measure against a reagent blank the absorbance of the solution at 410 mμ in a 1-cm cell. The reagent blank is prepared by adding

TABLE 1

Determination of Nitrates With Zinc-Copper Reduction

Nitrate Nitrogen in Distillate *mg*	Absorbancy (A_s) Calibration	Absorbancy (A_s) Samples					Avg $\bar{x}$	Range R	Standard Deviation σ*	$\frac{\sigma}{\%}$
		River Water								
0.050	0.097	0.097	0.087	0.092	0.093	0.092	0.092	0.010	0.0064	6.6
0.10	0.194	0.189	0.181	0.189	0.184	0.191	0.187	0.010	0.0091	4.7
0.25	0.471	0.478	0.490	0.475	0.480	0.471	0.479	0.019	0.011	2.4
0.35	0.670	0.682	0.665	0.678	0.680	0.682	0.677	0.017	0.011	1.6
0.50	0.940	0.965	0.945	0.960	0.950	0.960	0.956	0.020	0.020	2.1
		Sewage Effluent								
0.050	0.097	0.104	0.093	0.096	0.096	0.099	0.098	0.011	0.0042	4.3
0.10	0.194	0.204	0.195	0.191	0.201	0.199	0.198	0.013	0.0068	3.5
0.25	0.471	0.492	0.472	0.472	0.488	0.487	0.482	0.020	0.016	3.3
0.35	0.670	0.680	0.678	0.675	0.692	0.689	0.683	0.017	0.016	2.4
0.50	0.940	0.980	0.970	1.00	0.970	0.985	0.981	0.030	0.047	5.1

* The equation for determining standard deviation is: $\sigma = \sqrt{\frac{\Sigma(x - x_{\text{calib.}})^2}{n - 1}}$.

100 ml ammonia-free water to a 150-ml beaker and treating this water in the same way as the sample solution. Determine the nitrogen present in the sample from the calibration curve.

Applications

Studies were made to show the applications of the proposed procedure for the determination of nitrates in river water and sewage effluent samples. Each sample solution was prepared by adding 25.0-ml portions of river water or effluent and known volumes of standard nitrate solution to a 150-ml beaker, followed by the addition of water to bring the final solution volume to 75 ml.

The results of the zinc-copper reduction are given in Table 1. The nitrogen values are the amounts of reduced nitrate present in the distillate.

Alkaline Ferrous Sulfate–Silver Sulfate Reduction

It was believed that the nessler reagent might be useful in the determination of nitrates following reduction by the alkaline ferrous sulfate–silver sulfate technique.

Reagents

Ferrous sulfate solution. Dissolve 5 g $FeSO_4 \cdot 7H_2O$ in 95 ml water. Prepare this solution daily.

Sodium hydroxide solution. Dissolve 20 g in 180 ml water.

Silver sulfate. Use a saturated solution.

Effect of Variables

The procedure used to study the effect of variables was the same as that previously reported (*4*), except that no buffer solution was used, and the ammonia in the distillate was determined by nesslerization.

Because the nesslerization-ammonia method is not as sensitive as the pyridine-pyrazolone method, it was suggested that the distillation technique (*4*) be revaluated for the higher nitrogen values, with emphasis placed on volume of distillate, pH of solution in the kjeldahl flask, and rate of distillation. It was found that the recovery of ammonia by distillation was dependent upon the pH of the solution being distilled. For nitrogen values up to 0.5 mg, quantitative recovery of ammonia was obtained if the pH was 11 or higher. Twenty milliliters of 10 per cent sodium hydroxide solution was sufficient for both the reduction and subsequent distillation. For the higher nitrogen values, it was necessary to distill two 50-ml portions to obtain the quantitative ammonia recovery. Without seriously affecting the sensitivity of the method, one 90–95-ml portion of distillate may be obtained. A rate of distillation of 6–10 ml/min is satisfactory for this larger volume of distillate.

To minimize the loss of ammonia, it was unnecessary to put any boric acid solution into the volumetric flask used as a receiver. With the adapter placed over the tip of the condenser and inserted a short distance into the flask, no loss of ammonia occurred. With the single portion of distillate, it was found that 2.0 ml nessler reagent was necessary for complete color development.

Procedure

Apparatus. Assemble the steam distillation apparatus with the condenser supported in a vertical position. Steam out the entire apparatus before each series of determinations.

Preparation of calibration curve. Put 5.0-, 10.0-, 25.0-, 35.0-, and 50.0-ml portions of the standard nitrate solution, Solution *A*, into five 500-ml kjeldahl flasks, and dilute to 50 ml with ammonia-free water. Proceed as described under "desired constituent." Plot milligrams of nitrate nitrogen against absorbancy. Prepare a new calibration curve for each preparation of nessler reagent.

TABLE 2

Determination of Nitrates With Alkaline Ferrous Sulfate–Silver Sulfate Reduction

Nitrate Nitrogen Added *mg*	Absorbancy (A_s) Calibration	Absorbancy (A_s) Samples					Avg $\bar{x}$	Range *R*	Standard Deviation σ*	$\frac{\sigma}{\%}$
		River Water								
0.050	0.103	0.107	0.102	0.108	0.097	0.107	0.104	0.011	0.0049	4.8
0.10	0.207	0.205	0.200	0.201	0.198	0.200	0.201	0.007	0.0074	3.6
0.25	0.515	0.515	0.510	0.510	0.514	0.494	0.509	0.021	0.011	2.1
0.35	0.719	0.690	0.694	0.690	0.694	0.694	0.692	0.004	0.030	4.2
0.50	0.985	0.970	0.980	0.980	1.010	0.990	0.986	0.040	0.015	1.5
		Sewage Effluent								
0.050	0.103	0.111	0.102	0.102	0.111	0.099	0.105	0.012	0.0060	5.8
0.10	0.207	0.215	0.208	0.208	0.211	0.210	0.210	0.007	0.0048	2.2
0.25	0.515	0.510	0.506	0.504	0.496	0.502	0.504	0.014	0.014	2.7
0.35	0.719	0.710	0.704	0.714	0.720	0.712	0.712	0.016	0.0098	1.4
0.50	0.985	0.965	0.995	0.955	0.950	0.980	0.969	0.045	0.026	2.6

* The equation for determining standard deviation is: $\sigma = \sqrt{\frac{\Sigma(x - x_{\text{calib.}})^2}{n - 1}}$.

Sample. Obtain a representative liquid sample. If nitrites are present, determine their nitrogen equivalent on a separate portion of the sample, and subtract this value from the total nitrogen value found for the sample. Measure by volume an amount of sample containing from 0.05 to 0.5 mg nitrate nitrogen.

If ammonia is present, put the sample into a 150-ml beaker. If the sample volume is less than 50 ml, dilute approximately to this volume with ammonia-free water. Add 0.5 ml sodium hydroxide solution, cover with a watch glass, and evaporate the sample solution to about half its volume. The addition of several glass beads will prevent bumping. If a precipitate has formed, add concentrated sulfuric acid dropwise until it just dissolves. Transfer the clear solution and three rinsings to a 500-ml kjeldahl flask. The volume of sample solution in the flask should be about 50 ml.

If ammonia is absent, place the sample directly in a 500-ml kjeldahl flask. If the sample volume is less than 50 ml, dilute approximately to this volume with ammonia-free water.

Desired constituent. Put a 100-ml volumetric flask under the tip of the condenser. Place a short glass adapter

up over the tip of the condenser, and insert the bottom of the adapter a short distance into the neck of the flask.

Add to the kjeldahl flask 1 ml of the silver sulfate solution, 7 ml of the ferrous sulfate solution, and 20 ml of the sodium hydroxide solution. Swirl the flask and connect it into the distillation assembly. Allow steam from the round-bottomed flask to enter the kjeldahl flask at such a rate that the rate of distillation is from 6 to 10 ml/min. Distill approximately 95 ml.

Mix the contents of the flask. Add 2.0 ml nessler reagent, dilute to the mark with ammonia-free water, and mix well.

After 10 min, measure against a reagent blank the absorbance of the solution at 410 mμ in a 1-cm cell. The reagent blank is prepared by treating 50 ml ammonia-free water in the same manner as the sample solution. From the calibration curve, determine the nitrate nitrogen or nitrate plus nitrite nitrogen present in the sample.

Applications

A study was made to show the application of the above procedure for the determination of nitrates in river water and sewage effluent samples. Each river water sample solution was prepared by adding to the kjeldahl flask known volumes of standard nitrate solution, 25.0 ml river water, and enough ammonia-free water to bring the final volume to about 75 ml. Because the sewage effluent contained an appreciable amount of ammonia, each effluent sample was prepared by adding to a 150-ml beaker known volumes of standard nitrate solution, 25.0 ml effluent, and enough water to bring the final volume to about 75 ml.

The results of this study are given in Table 2.

Conclusions

The statistical studies reveal that both suggested procedures produce better methods for the determination of reduced nitrates than the pyridine-pyrazolone method (*4*). Ammonia and nitrite ions interfere in all three methods, but their removal or determination takes only a short time. The distillation techniques are rapid and separate the ammonia from other substances that might interfere with the nesslerization procedure. The alkaline ferrous sulfate–silver sulfate reduction is superior to the zinc-copper couple reduction because it requires less time for analysis, is more sensitive, and results in both a quantitative reduction of nitrates and recovery of all ammonia produced. Neither suggested procedure requires extreme care in technique.

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Suggested Method for Boron Determination With 1,1'-Dianthrimide

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INTEREST in the boron content of public water supplies is relatively new, although the concentration of boron has long been recognized as an important factor to be considered before a rating can be made of the suitability of a water for irrigation. This new interest stems from indications in recent toxicological studies made by USPHS of the probable physiological significance of the element in drinking water.

Boron may enter public water supplies from the natural leaching of rocks and soils or from direct pollution of rivers and ground waters. Boron compounds are used by many industries that discharge wastes into streams. Because of the continuing efforts of cities, states, and federal agencies to maintain or improve the quality of water supplied to the consumer, attention given to the determination of boron probably will increase.

To be practical and to provide the kind of data needed in water plants or public health laboratories, the analytical method for testing water must be very sensitive, insusceptible to interferences, easy to perform, and must not demand an excessive volume of sample. The method to be described is based on a chemical reaction developed in 1949 by Ellis, Zook, and Baudisch (*1*) for the analysis of boron in plant material. Chemical interferences and manipulative difficulties in applying this reaction to water analysis have been delimited and resolved without resort to tedious and time-consuming steps. Since 1951, various water laboratories of the USGS have used this dianthrimide method routinely, in preference to published procedures.

Twenty determinations require an average manipulation time of 2 hr. Results generally are accurate and reproducible to ± 0.1 μg, which means that boron concentrations less than 1 mg/l can be measured to ± 0.02 mg/l in 5 ml of water. Smaller volumes of sample, or dilutions, are used in the higher concentration ranges. The procedure requires few special analytical techniques and little training, and differences in individual techniques are minimized by instrumentation.

1. General Discussion

1.1. *Principle.* The method uses the reaction of boron with 1,1'-dianthrimide in concentrated sulfuric acid, which produces a color change from greenish yellow to brilliant blue. At a wavelength of 620 mμ, the light absorbance of 5.0 μg of boron is about 1.2. The reagent is soluble in concentrated sulfuric acid, but precipitates in the presence of traces of moisture. At the elevated temperature of the reaction, hygroscopic moisture presents

no problems. Stoppered reaction vessels are adequate protection at lower temperatures.

The reaction producing the blue color depends on the nature of the vessel in which the reaction occurs, the temperature and duration of heating, and the concentration of reagent and boron. In platinum, the reagent is unstable and darkens without producing the blue color. Both porcelain and glass are satisfactory.

Maximum color development is obtained after the reaction has proceeded for 3 hr at 90°C. At room temperature the reaction is extremely slow, if it occurs at all. Increased temperature increases the reaction rate, but the timing for maximum color development becomes critical, and the sensitivity between runs is variable.

When the prescribed reagents and procedure are used, the relationship of the intensity of the color complex developed is linear in the 0–5-μg range. The concentration range in the linear segment of the curve can be extended by increasing reagent strength, but only with attendant decrease in sensitivity. Nonlinearity in the concentration-absorbance curve can result from weak or deteriorating reagents. Some boric acid is probably volatilized during the initial evaporation of the sample in the presence of sulfuric acid. Prolonged heating or temperatures higher than 90°C volatilize an excessive amount of boron and decrease the sensitivity of the test. The loss, however, is proportional to the boron content of the sample and standard; hence, such loss in no way affects the linearity of the color development if the heating is uniform.

1.2. *Interference.* Ellis and others (*1*), in studies of plant material, found that sulfate, chloride, sodium, potassium, calcium, magnesium, zinc, copper, manganese, aluminum, and beryllium did not interfere with the reaction, but nitrate and several oxidizing agents did. Preliminary investigations by the author indicated that, of the ions commonly present in water, both nitrate and alkalinity (CO_3-HCO_3) caused off colors of the boron-dianthrimide complex. This interference is removed by evaporating the sample in the presence of sulfuric acid. During the evaporation of 5 ml of sample mixed with 1 ml of concentrated sulfuric acid, nitrate and bicarbonate are distilled off as nitric acid, water, and carbon dioxide. In this single step the sample also is dehydrated completely, and the boron is converted to the acid form that is required for the reaction with 1,1′-dianthrimide.

Tests with standard solutions containing 0–2,000 mg/l bicarbonate, 0–200 mg/l nitrate, and 0.00–1.00 mg/l boron indicated that acid evaporation is an effective means of removing bicarbonate and nitrate interferences. Deviations between the amount of boron present and that found in 31 tests did not exceed ±0.02 mg/l.

Few other oxidizing or reducing substances that might interfere with the reaction are common to waters analyzed by the USGS. Consequently, this type of interference has not been studied extensively. The effects of residual chlorine were tested by analyzing standards containing 0.40 mg/l boron and up to 13 mg/l residual chlorine (added as hypochlorite). Results indicated no perceptible interference. Presumably, the number of possible oxidizing and reducing interferences in water analysis are limited to those not volatilized or decomposed in concentrated sulfuric acid at 90°C during the first phase of the procedure. Never-

TABLE 1

Effectiveness of Hydrogen Peroxide for Removal of Organic Interference

Boron Present mg/l	Albumin Added mg/l	Boron Found mg/l	Deviation mg/l
0.40	100	1.08*	—
0.00	50	−0.01	−0.01
0.40	50	0.39	−0.01
0.00	100	−0.03	−0.03
0.40	100	0.40	0.00
1.00	100	1.00	0.00

* No hydrogen peroxide added, off color.

theless, if the procedure is applied to the analysis of industrial wastes, additional study is recommended commensurate with the nature of the waste products.

Large quantities of soluble organic material may interfere with the borondianthrimide reaction to produce off colors of the complex. This interference is easily recognized. The mechanism is not clearly understood and probably varies with the type of organic material. Duplication of naturally occurring soluble organic material in the laboratory is practically impossible, but the effects of soluble albumin as a source of nitrogenous organic material have been investigated. Table 1 shows the effectiveness of 1-hr digestion with 1 ml of 10 per cent hydrogen peroxide at 90°C prior to acid evaporation. The value for the nontreated standard is included in Table 1 only for comparative purposes. The color of this reacted standard was not a true color of the borondianthrimide complex. In the few instances of color interferences encountered in routine analysis of natural waters, however, oxidation with hydrogen peroxide has been successful. When peroxide digestion is used, all nascent oxygen must be volatilized before the dianthrimide is added, and the color complex of the sample should be compared with the standard boron solutions similarly treated.

Tolerance of the method for high concentrations of dissolved material is remarkably good. Sodium chloride was used to simulate the effects of large concentrations of dissolved solids in the test with standard boron solutions, reported in Table 2. The high result at the concentration of 100,000 mg/l sodium chloride resulted from the mechanical interference of precipitates with the light beam, rather than from interference with the chemistry of the reaction. Any insoluble precipitate in the cuvette is a potential source of mechanical error. Because the solubility of various salts in concentrated sulfuric acid differs so widely, no uniform concentration tolerance for dissolved solids can be set.

2. Apparatus

2.1. *Oven,* at 90°C. Uniform temperature throughout the oven is imperative, but any good convection oven is satisfactory.

2.2. *Spectrophotometer or electrophotometer,* with a wavelength of 620 mμ and round optical cells with a light

TABLE 2

Effect of Salt on the Dianthrimide Method at 0.40-mg/l Boron Level

Sodium Chloride Added mg/l	Boron Found mg/l
1,000	0.39
4,000	0.42
10,000	0.41
40,000	0.42
100,000	0.45*

* High result caused by mechanical interference of precipitate.

path of 23 mm or 25 mm. Spectrophotometric data * are as follows:

Phototube: blue sensitive
Blank: twice-distilled water carried through the procedure with the samples
Initial sensitivity setting: 2
Slit width: approximately 0.6 mm.

2.3. *Stoppers,* polyethylene or rubber, to fit optical cells.

3. Reagents

3.1. *Sodium tetraborate,* 1.00 ml = 0.001 mg B. Dilute 10.00 ml $Na_2B_4O_7$ (1.00 ml = 0.100 mg B) to 1,000 ml with twice-distilled water. Store in a plastic bottle.

3.2. *Sodium tetraborate,* 1.00 ml = 0.100 mg B. Dissolve approximately 10 g $Na_2B_4O_7 \cdot 10H_2O$ in twice-distilled water at 50°–60°C. Recrystallize by placing in a refrigerator for several hours. Dry by removing the water with suction and washing with alcohol, then with ether. Do not dry in the oven. Dissolve 0.8813 g in twice-distilled water, and dilute to 1,000 ml. Store in a plastic bottle.

3.3. *Sulfuric acid,* concentrated (sp gr 1.84).

3.4. *Dianthrimide working reagent.* Dilute 1 volume of stock reagent to 20 volumes with concentrated H_2SO_4 (sp gr 1.84). The reagent is stable for long periods of time in glass ampules or in containers sealed with sealing wax and kept in the refrigerator.

3.5. *Dianthrimide stock reagent.* Dissolve 200 mg in 50 ml of concentrated H_2SO_4 (sp gr 1.84). The reagent is stable for long periods in glass ampules or in containers sealed with sealing wax and kept in the refrigerator.

4. Procedure

4.1. Pipet a volume of clear sample containing less than 0.005 mg of boron into optical cells, and adjust the volume to 5 ml. Prepare a blank of twice-distilled water and standards containing 0.002 and 0.005 mg of boron, and adjust the volume to 5 ml.

TABLE 3

Recovery Checks of Boron Added to Natural Waters

Boron Concentration—*mg/l*			
No Addition	After Addition of 0.20 *mg/l*		Deviation From Theoretical
Found	Theoretical	Found	
0.20	0.40	0.39	−0.01
0.26	0.46	0.47	+0.01
0.30	0.50	0.50	0.00
0.32	0.52	0.52	0.00
0.42	0.62	0.61	−0.01
0.48	0.68	0.69	+0.01
0.55	0.75	0.74	−0.01
0.80	1.00	1.00	0.00
1.03	1.23	1.25	+0.02
1.05	1.25	1.29	+0.04

4.2. To all, add 1.0 ml of concentrated H_2SO_4, and mix well.

4.3. Evaporate to 1 ml or less in an oven at 90°C. Overnight evaporation is usually sufficient to dehydrate the solutions, but inadequate circulation around the tubes or extremely high humidity may necessitate a slightly longer evaporation period.

4.4. Add 5.0 ml of working reagent, mix well, and incubate for 3 hr at 90°C.

* From the Beckman Model B spectrophotometer; a product of Beckman Instruments, Fullerton, Calif.

4.5. Cool, dilute with 10.0 ml of concentrated H_2SO_4 to raise the solution level in the cuvettes above the light beam, and mix. Stopper and clean outside of the cuvette. Care must be taken to avoid contamination if rubber stoppers are used.

4.6. Determine the absorbance of the standards and the samples against the blank at a wavelength of 620 mμ.

5. Calculation

Determine the quantity of boron in the sample from a plot of absorbancies of a standard containing known amounts of boron.

$$\text{mg/l B} = \frac{1{,}000 \text{ (mg B in sample)}}{\text{ml sample}}.$$

6. Precision and Accuracy

The overall precision of the method is computed from a total of eighteen tests with standard solutions. These tests included three replicates, run on three separate days, at six concentration levels, each from 0.00 to 1.00 mg/l of boron. Precision expressed as the standard deviation is 0.007 mg/l. There is no significant difference in precision at different concentration levels.

The true accuracy of a method, obtainable under normal operating conditions and with the variety of water types encountered in laboratory operations, is difficult to measure. Recovery checks are a means of approximating accuracy; they were run as follows: Samples of water were selected from ten sources having different chemical composition and boron concentrations. Duplicate 5-ml samples were pipetted. Boron was determined in one set of samples. Then, 1 μg of boron (equivalent to 0.20 mg/l) was added to the other set, and boron was determined. Table 3 shows the results of these determinations. The standard error of the method as computed from this test is 0.012 mg/l.

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Suggested Revision of Phenol Red Method for Bromide

Eugene Goldman and David Byles

A contribution to the Journal by Eugene Goldman, Chemist, and David Byles, both of the San. Eng. Div., Dept. of Water & Power, Los Angeles, Calif.

THE phenol red method for bromide has become more precise, owing to the selection of: [1] the optimum time interval between the addition of chloramine T (sodium *p*-toluene sulfonchloramide) to oxidize the bromide and the addition of sodium thiosulfate to reduce the chloramine T, and [2] the optimum concentration of chloramine T and thiosulfate.

Many workers using phenol red to determine bromide refer to a fading of the color and the uncertain results that follow. A number of workers have reported the elimination of this fading with the use of sodium thiosulfate as a fixing agent. A test was carried out to see if fading could be stopped by sodium thiosulfate and to ascertain the concentration of sodium thiosulfate required.

A number of samples with a concentration of 0.5 mg/l bromide and an equal number of blanks were prepared. All received the same amount of buffer and indicator. To the first two pairs of sample and blank, 0.6 ml of 4.25-mg/ml chloramine T solution was added; 15 min later, 0.5 ml of distilled water was added. With the remaining sample-blank pairs the same procedure was carried out, except that 0.5 ml of various concentrations of sodium thiosulfate was substituted for the distilled water. The samples were then read on the photometer at approximately 0.5, 1, and 3 hr after the addition of the chloramine T.

From the results of this test, it was concluded that with the addition of 0.5–5.0 millimoles of sodium thiosulfate to the treated 50-ml sample, the fading of color was sufficiently eliminated so that the photometer could be read accurately. The use of this amount of sodium thiosulfate does not, apparently, disturb the test for bromide. The optimum time between the addi-

TABLE 1

Analysis of Southern California Waters, Using the Revised Phenol Red Method

Source of Water	Chloride mg/l	Sulfate mg/l	Bromide mg/l
Metropolitan Water District	81	265	0.38
Lower San Fernando Reservoir	19	20	0.34
Erwin Well No. 4	14	58	0.47
Hot Creek at County Road	22	12	0.34
Arroyo Seco, waste water	93	266	0.65
Scattergood steam plant area, Playa Del Rey, sea water	16,600		53

tion of chloramine T and the addition of thiosulfate was found to be 20±5 min at temperatures of 20–25°C. No serious photochemical effects were noted at this time interval.

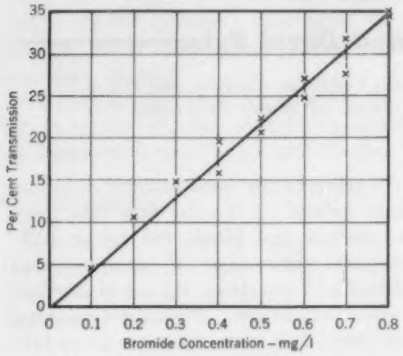

Fig. 1. Standard Bromide Curve

The straight line is the best approximation of the root mean square. The probable error in the ordinate is 1.03; in the abscissa, 0.022. Per cent transmission is plotted from the -log per cent transmission relative to the reagent blank.

Increasing the concentration of chloramine T solution from the 1.25 mg/ml mentioned by Houghton (*1*) to 5.0 mg/ml, has the twofold effect of changing the color of the blank from dirty yellow to violet or purple—which increases the resolution of the test—and, at the same time, decreasing slightly the effect of the oxidizing or reducing agents present. The change in color of the blank probably comes from a compound that chloramine T forms with phenol red. (Chlorine water does not show this effect.) The best wavelength for spectrophotometric examination * was found to be 590 mμ. A typical standard curve indicating the precision of the method, and the results of the analysis of waters from the Southern California area, are shown in Fig. 1 and Table 1, respectively. The details of the revised method follow.

Phenol Red Method for Bromide

Bromide may occur in varying amounts in well water along coastal areas as a result of sea water intrusion. The bromide content of some ground waters has been ascribed to connate water. The bromide found in some fresh-water streams may come from industrial discharges.

1. General Discussion

1.1. *Principle.* Phenol red changes in color from yellow to red over a pH range of 6.4–8.0. With dilute hypobromite, phenol red forms an indicator of the bromphenol blue type, which changes from yellow to blue-violet over a pH range of 3.2–4.6. The oxidation of the bromide and the bromination of the phenol red take place readily in the presence of chloramine T. When the color comparison is made at a pH of 5.0–5.4, the brominated compound will appear reddish to violet, depending upon its concentration. Thus, a sharp differentiation can be made between varying quantities of bromide. The concentration of chloramine T and the timing of the reaction before dechlorination are critical.

1.2. *Interference.* Materials present in ordinary tap water do not interfere.

2. Apparatus

2.1. *Colorimetric equipment.* One of the following is required:

a. Spectrophotometer, for use at 590 mμ, providing a 1-cm light path.

* The spectrophotometer used was the Beckman Model DU, a product of Beckman Instruments, Inc., Fullerton, Calif.

b. Filter photometer, providing a 1-cm light path and equipped with a yellow filter having a maximum transmittance at 590 mμ.

c. Nessler tubes, matched, 100-ml, tall-form.

2.2. *Timer.*

2.3. *Acid-washed glassware.* All glassware must be washed with 10 per cent HNO_3 and rinsed with distilled water to remove all trace of adsorbed bromide.

3. Reagents

3.1. *Acetate buffer solution.* Dissolve 68 g of sodium acetate trihydrate, $NaC_2H_3O_2 \cdot 3H_2O$, in distilled water. Add 30 ml of glacial acetic acid, and make up to 1 liter. The pH should be 4.6–4.7.

3.2. *Phenol red indicator solution.* One of the following standard indicator solutions may be used:

a. Dissolve 0.021 g of phenolsulfonephthalein sodium salt, and dilute to 100 ml with distilled water.

b. Dissolve 0.020 g of phenolsulfonephthalein in 2.84 ml of 0.02*N* NaOH, and dilute to 100 ml with distilled water.

3.3. *Chloramine T solutions.* Dissolve 0.500 g of chloramine T, and dilute to 100 ml with distilled water. Store in a dark bottle and refrigerate.

3.4. *Sodium thiosulfate solution,* approximately 2*M*. Dissolve 49.6 g of $Na_2S_2O_3 \cdot 5H_2O$ or 31.6 g of $Na_2S_2O_3$, and dilute to 100 ml with distilled water.

3.5. *Stock bromide solution.* Dissolve 0.7446 g of dried, reagent grade potassium bromide (KBr) in distilled water, and make up to 1,000 ml. This solution contains 500 mg/l Br.

3.6. *Bromide working solution.* Dilute 10.00 ml of bromide stock solution to 1,000 ml with distilled water; 1.00 ml = 0.005 mg Br.

4. Procedure

4.1. To 50 ml of sample containing 0.1–1.0 mg/l bromide, add 2 ml of buffer solution, 2 ml of phenol red solution, and 0.5 ml of chloramine T solution. Mix thoroughly. Exactly 20 min after the chloramine T addition, dechlorinate by adding, with mixing, 0.5 ml of sodium thiosulfate solution. Compare visually in nessler tubes against bromide standards prepared simultaneously, or, preferably, read in a photometer at 590 mμ and determine the bromide values from a calibration curve.

4.2. Prepare standards by diluting aliquots of the bromide working solution to 50 ml. One milliliter of the working solution diluted to 50 ml is equivalent to 0.1 mg/l Br.

4.3. Construct a calibration curve consisting of 10–15 points in the concentration range of 0.1–1.0 mg/l Br. Read standards at 590 mμ, using a spectrophotometer or a filter photometer against a distilled water blank. Plot concentration against per cent transmission on semilog paper.

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Salvaging Heat From Modern Recarbonation Equipment

Glenn E. Hands and J. Robert Popalisky

A contribution to the Journal by Glenn E. Hands, Prin. Engr., Burns & McDonnell Eng. Co., Kansas City, Mo., and J. Robert Popalisky, Asst. Chief Engr. & Supt., Water Dept., Kansas City, Mo.

WHEN recarbonation was first employed for the stabilization of lime-softened water, the required carbon dioxide was usually found in abundance at water plants in the stack gases of steam generators (boilers) that furnished power for the pumping of water, heating the buildings, or generating power.

Difficulties of Recarbonation

Obtaining stack gases from these old units for salvage of the carbon dioxide presented many problems to both the designer and the operator of the recarbonation equipment.

The fuel frequently burned was coal of various grades, depending upon availability. Later, crude oils were used and then the finer grades of fuel oil. Finally, natural gas became almost universally available. Combustion controls on the older units were usually quite crude and depended upon the ability of, and the attention given by, the operators. Firing that was satisfactory for (or at least not detrimental to) the primary use of the fuel would frequently produce gases entirely unsatisfactory for use in water treatment. For example, partial combustion of the fuels for steam generation would reduce the thermal efficiency of the plant to some extent, but it could be and was tolerated for a time with no disastrous effects to the plant. The noxious gas would be discharged through chimneys high enough to cause only an occasional complaint. Smoke abatement was, perhaps, the best argument for better firing equipment and better operation of the equipment.

Gases from partially burned fuels were quite unsatisfactory for recarbonation, however. The products of partial combustion, such as carbon, oils, hydrocarbons, phenols, and sulfides, produced intolerable tastes and odors in the water. To overcome this frequently encountered problem, scrubbers were almost universally included as a part of the recarbonation equipment. Occasionally dust filters were added.

Scrubbers were designed to remove the objectionable gases, carbon, and ash from the flue gases, but in the process they removed a large percentage of the carbon dioxide as well. It is estimated that 20–30 per cent of the carbon dioxide produced was lost in a gas scrubber.

Because the gases had to be bubbled up through several feet of water in the recarbonation basins (10–12 ft in old plants) they had to be compressed. The problems of compressors were familiar to many operators.

Salvage of Carbon Dioxide

In Kansas City, Mo., the first recarbonation facilities were installed in

1944 to salvage flue gases from the central heating plant. Each of the three 75-hp steam-producing boilers was rated at 12,500 sq ft of equivalent direct radiation (EDR) for heating the water plant. It was estimated that this equipment could produce approximately 11 tons of carbon dioxide per day from two of the three boilers. The fuel in use at that time was bituminous coal and ASTM No. 6 fuel oil. This oil was so thick and viscous that heat was necessary to make it flow from storage tank to burner.

The flue gases were cooled and cleaned by means of two scrubbing chambers in which they were subjected to water sprays as they passed up through a system of baffles and trays to the suction side of the gas compressors. Three 1,000-cfm rotary pumps compressed the gases and sent them on to the basins for recarbonation of the lime-softened water. As originally installed, this system was able to take care of recarbonation for the entire plant, but difficulties soon developed.

The compressors became so severely corroded that all units had to be replaced. Metals that were more corrosion-resistant were used in replacement parts, but it was evident that each compressor would require complete overhaul every 6 months. This became routine and was scheduled when carbon dioxide requirements were at a minimum.

The use of coal was discontinued, and there was some improvement. Apparently, sulfur in the fuel was forming sulfuric acid beyond the scrubber as the gases were cooled below their dew point. Finally, natural gas and ASTM No. 2 fuel oil were used in place of the heavier oils. The problem was thereby reduced until maintenance was more nearly normal. The Kansas City experience was typical of difficulties at many plants throughout the country.

Disposal of Surplus Heat

The dual use of fuel-burning equipment introduced other problems. For example, frequently the requirements for carbon dioxide exceeded the requirements for the original purpose of the burner and made it necessary to burn fuel without using the heat. Such surplus heat must be disposed of in some satisfactory manner. Disposing of the heat through the radiators of the heating system adds to the discomfort of the operators and accelerates the rate of deterioration of equipment. The heat problem often becomes intolerable.

Many devices have been tried for disposing of surplus heat. The generated steam has been discharged into the atmosphere through relief valves, or discharged under water through a perforated pipe, or passed through heat exchangers immersed in an open tank or flume. Relief valves to the atmosphere have not been satisfactory because the valves are costly to maintain and frequently out of order. Discharge under water through a perforated pipe has caused severe chatter because of the collapse of steam in the diffuser pipe. Heat exchangers, when properly designed and installed, have been quite successful.

Modern Carbon Dioxide Producers

Approximately 10 years ago, equipment manufacturers developed a line of carbon dioxide generators that overcame, to a large extent, the objections to equipment designed for other purposes and adapted to recarbonation service. To overcome the problems of compression and corrosive gases, the air and fuel (where necessary) were compressed before combustion. Com-

bustion occurred under pressure in a specially designed firebox where the fuel-air ratio was carefully controlled to assure complete combustion. The flue gases were cooled in two stages: first by a jacket of water around the firebox and next by a heat exchanger in the exhaust line. The cooling water was used once and drained to waste. Heat-salvaging equipment was not available. It was considered quite impracticable to provide such dual-purpose equipment.

During the past 8 years, the Kansas City water utility has been in the process of expanding its water-softening and treatment plant from a capacity of 100 mgd to 210 mgd. At the same time, the plant has been modernized to improve operational efficiencies, reduce maintenance costs, and provide better protection against floods. Construction is still in progress, and some of the proposed improvements have been deferred, but many of the benefits of the improvements are now being fully realized.

One of the first steps taken was to provide greater recarbonation capacity. Recarbonation capacity was so deficient that the water department was forced to purchase up to 2 tons of dry ice per day at 10 cents per pound in order to fill its carbon dioxide needs. Four large generators, each producing 10,000 lb of carbon dioxide per day, were installed in 1953. These units provide the carbon dioxide require-

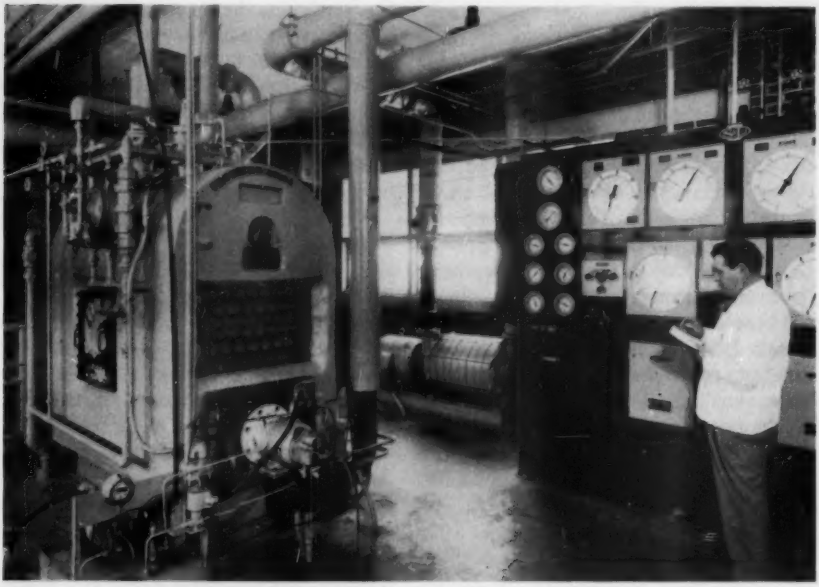

Fig. 1. Steam-Generating Carbon Dioxide Producers

The capacity of the generator shown is 7,000 lb/day of carbon dioxide; steam capacity is 5,000 sq ft EDR.

ments of the two final basins. The heated water from the cooling jacket and heat exchanger of the units is used to heat a pipe tunnel and three sludge-pumping stations. Thus, some of the heat, an amount approximately equal to the capacity of one producer, is salvaged.

The areas heated do not require precise temperature control. The main object of the heat is to prevent freezing in the tunnel and to provide sufficient comfort for workmen to service the equipment. For summer operation the heated water is diverted directly to the drain.

Salvage of Heat

In 1957 the water department installed six additional carbon dioxide producers (Fig. 1) adding 42,000 lb of carbon dioxide capacity per day, using standard heating plant boilers (steam generators) for salvaging the steam generated. The steam is used for heating the new extensions to the water treatment plant. The surplus steam, generated when more carbon dioxide is required but heat is not, is discharged through an automatic-injector, steam-operated water heater into the adjacent settling basin.

The boilers are modified for pressure firing. All joints in the firebox are welded closed and flanges are provided for necessary openings. Air and natural gas are compressed and delivered to the burner at sufficient pressure to overcome both friction losses and the depth of water through which the flue gases must pass.

The units are designed for burning No. 2 fuel oil as standby fuel when required. The standby fuel is necessary according to the contract with the local gas company for the purchase of natural gas at industrial rates.

Costs of Heat Salvage

The salvaging of the heat was economically justified. The annual fuel bill for heating the water plant alone was estimated at $12,000. By salvaging the heat from the carbon dioxide producers it was estimated that approximately $5,000 of heating expense could be saved per year. It was recognized that combined facilities would require more service and maintenance than separate units, but the extra cost was estimated at only $1,000 per year. The estimated net saving of $4,000 per year would justify an immediate expenditure of $38,500 for extra equipment based upon a 15-year life of the equipment and 5 per cent interest on the money invested. As the extra cost of such auxiliary controls and equipment as safety devices and steam lines for dual-purpose equipment was estimated at $34,800, the investment could be justified. As an extra boiler for heating alone, at $24,000, would have had to be purchased if dual-purpose equipment was not provided, the additional investment was actually only $10,800.

Operation

The total amount of capacity required for carbon dioxide production at the ultimate expanded plant capacity of 210 mgd is estimated at 104,000 lb per day (24 hr). This amount of carbon dioxide requires the burning of approximately 167 gph of ASTM No. 2 fuel oil, or 34,000 cfh of 1,000-Btu natural gas, and would produce 34,000,000 Btu/hr.

The maximum heating capacity required for the entire water treatment plant, including chemical building, filter building, pumping station, maintenance building, instrument shop, and

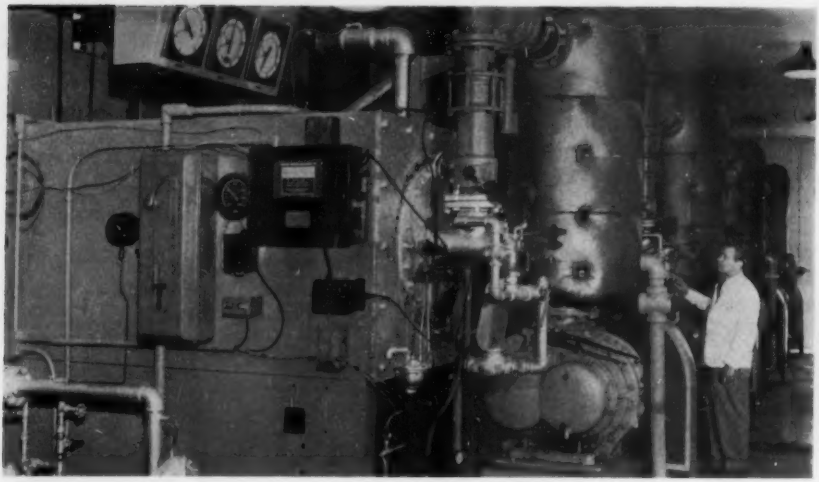

Fig. 2. Water-Jacketed Carbon Dioxide Producers

The capacity of each producer is 10,000 lb/day of carbon dioxide.

TABLE 1

Fuel Consumed in a Typical Year for Carbon Dioxide and Heat Production

Month	Chemical Building Boilers				Water-Jacketed CO_2 Producers		Steam-Generating CO_2 Producers			
	Gas Used *1,000 cu ft*		Oil Used *gal*		Gas Used *1,000 cu ft*	Oil Used *gal*	Gas Used *1,000 cu ft*		Oil Used *gal*	
	CO_2	Heat	CO_2	Heat	CO_2	CO_2	CO_2	Heat	CO_2	Heat
January	3,391	1,792	3,361	1,239	6,230	4,109	4,860		1,610	
February	3,936	833	2,899	2,670	6,750	5,241	3,380		2,265	
March	3,686	2,822	2,917	20	6,350		1,520		18,732	
April	3,563	627	4,503		4,270	6,512	2,490	59	2,575	
May	3,557		6,015		4,400	8,254	2,400	150	1,494	
June	3,633	114	5,510		1,050	19,656	2,560		6,091	
July	4,823				3,190	17,517	2,970		6,667	
August	4,850		3,008		5,330	6,450	3,590		5,951	
September	2,579		3,034		7,700	988	2,880			
October	3,934	38	607		8,850	6,887	2,150	390	96	
November	2,076	2,507	1,166		7,040	1,416	2,690		13,510	
December	2,405	2,921	1,711	1,147	6,140	6,346	4,170	150	5,985	198
Totals	42,433*	11,654	34,731	5,076	67,120†	83,385	35,660‡	749	64,976§	198

* 2,400 tons CO_2 produced.
† 67,120 tons CO_2 produced.
‡ 35,660 tons CO_2 produced.
§ 64,976 tons CO_2 produced.

garage, is 43,000 sq ft EDR, or 10,320,000 Btu/hr. Thus, it is apparent that only one-third of the total carbon dioxide–generating capacity need be dual purpose—that is, used for heating as well as for carbon dioxide production.

It was therefore planned to use the existing heating plant boilers for both heating and carbon dioxide production, burning either natural gas or No. 2 fuel oil.

Each of the three existing heating plant boilers has a capacity of 12,600 sq ft EDR, which represents a firm capacity of 25,200 sq ft EDR. Subtracting this from the total required capacity of 43,000 sq ft EDR, leaves a deficiency of 17,800 sq ft EDR to be provided in new facilities.

Each of the six new carbon dioxide producers (steam generators) has an EDR capacity of 5,000 sq ft for heating purposes, making available 30,000 sq ft EDR. Therefore, more than 12,000 sq ft EDR of excess heating capacity is available in the new units required. It was recognized, however, that with basins out of service and other exigencies of operation a substantial reserve of capacity for heating was justified. Therefore, all of the new producers were used and connected to the steam heating system.

Temperatures in the new filter building, pipe gallery, pumping station offices, chemical building, and laboratories are regulated by thermostats. If more steam is generated than is required for heating, it is discharged automatically through an ejector-type water heater submerged in one of the settling basins.

The system has worked very satisfactorily. Most of the time carbon dioxide production requires more fuel than is required for heating. There have, however, been occasions when the reverse has happened. Occasionally, because of necessary maintenance of basins, boilers have had to be fired for heat only. As anticipated, it is not always possible to furnish the entire heating load from carbon dioxide production alone, but more than enough fuel is saved to justify the expenditure for the dual system.

In the summer months most of the energy is dissipated, but at the new chemical building steam is used for operating two 25-ton air-conditioning units, for heating water to chemical feeders, and for laboratory and personnel use.

Fuel Costs

Table 1 shows a typical year (1958) of fuel consumption for carbon dioxide production and for heat. The amounts shown for heat are for extra fuel consumed for heat and not required for carbon dioxide production.

The total cost of fuel for heating and for carbon dioxide production was $55,064. The extra cost of fuel for heating alone was $3,291. It is estimated from these figures that if all heating had been done separately, the heating bill would have been $12,960. Thus, the probable savings in salvaging heat for one year was $9,669. Of this, $4,949 was saved by the heating plant boilers and $4,720 was saved by the carbon dioxide producers.

Feedwater Treatment

The boiler feedwater and the jacket water for nonboiler carbon dioxide producers (Fig. 2) require treatment in order to prevent scaling and foaming. Because so much of the water is used only once and discharged to waste as a means of dissipating the energy, this treatment is more important and tedious in dual-purpose units. Boiler water in the heating plant boil-

ers requires only occasional treatment with trisodium phosphate, sodium sulfite, and a filming polyamine,* because most of the heat from these boilers is salvaged and the condensate is returned for reuse.

Because the makeup water of the water-jacketed carbon dioxide producers is not boiled or overheated (normally the temperature rise through the unit does not exceed 80°F), the only treatment required is with a polyphosphate. This treatment must be continuous, however, because the water is used only once and then discharged to waste.

Costs of Treatment

The steam-generating carbon dioxide producers require more careful attention and more extensive treatment. Presently a mixture of soda ash, trisodium phosphate, and starch is used. These chemicals are added through ball-type pressure chemical feeders as required according to the results of regularly performed analyses of the water. At first these analyses were made only once each week, but it was soon evident that more frequent analyses would be required. They are now made 3–5 times per week. It is estimated that the total labor cost of treating the makeup water in all units is $1,200 per year. This includes the time of the analyst. The extra labor cost resulting from the use of dual-purpose units is approximately two-thirds of this amount, or $800 per year.

The annual cost of the chemicals for treating the boiler feedwater of the heating plant is estimated to be $383 per year. The cost of the polyphosphate for treating the jacket water of the original carbon dioxide producers is $415 per year for the generation of 3,910 tons of carbon dioxide, or 8.4 cents per ton. The annual cost of the chemicals for the carbon dioxide steam generator units is $411 for the generation of 2,842 tons, or 14.4 cents per ton. Thus the extra annual cost of chemicals for the steam generators at 6 cents per ton is $171.

If the extra costs of labor ($800) and of chemicals ($171) are deducted from the fuel expense saved by the steam-generating carbon dioxide producers ($4,270), the net annual saving is reduced to $3,749, which is enough to pay for the extra cost of the dual unit in 3 years.

The average cost of natural gas at the industrial rate was 21.9 cents per 1,000 cu ft. The average cost of fuel oil was 10.9 cents per gallon. The cost of producing carbon dioxide from natural gas was 18.7 cents per 100 lb and from fuel oil, 46.4 cents per 100 lb.

Although progress has been made in salvaging the heat of carbon dioxide production, much remains to be done. At Kansas City, 83.7 billion Btu is wasted each year for the production of carbon dioxide. This is enough to hold the temperature in 1,400 homes at 75°F the year around.

* Filamine; a product of Dearborn Chemical Co., Chicago, Ill.

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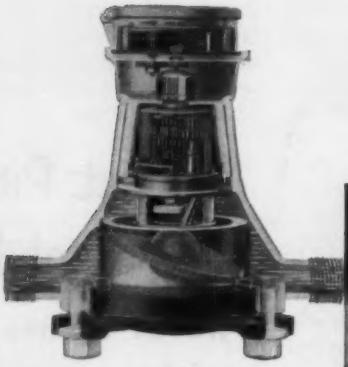

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Trident interchangeability is the big reason. Parts made for the most up-to-date Tridents are designed to fit into any older Trident of the same size and type. Reordering and stock control are simplified, too. No need to keep parts for many models. Just stock a small supply of the latest Trident parts.

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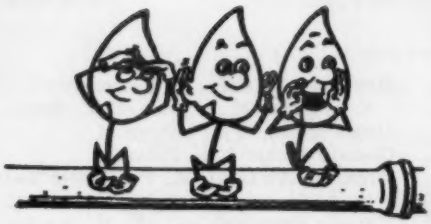

Percolation and Runoff

FIFTY-NINERS in the haunts of Forty-niners were the 3,211 AWWA-'ers who set a registration record at the Association's Annual Conference last month in San Francisco. And if they didn't whoop it up quite as riotously as their antecessors might have, perhaps it was as much because of the work to be done as the presence of 785 wives. At any rate there was a full measure of both work and play for everyone, and everyone seemed particularly intent upon obtaining full measure.

From the time things got under way on Sunday, Jul. 12, with an exhibit open house featuring more than 200 boothfuls of the latest and best in water works equipment and materials, produced by no less than 108 AWWA Associate Members, until new President Lauren Grayson adjourned the meeting of the Board of Directors on Friday, Jul. 17, busyness was the order of the week—of "American Water Works Week," that is, by proclamation of Mayor George Christopher:

WHEREAS, the American Water Works Association is a splendid organization which, during the 79 years of its existence, has been most effective in establishing policies and standards of far-reaching importance to the vital water works industry of our nation; and

WHEREAS, in its progressive program it has been instrumental in increasing the public appreciation of all that public water supply means to urban life and development; and

WHEREAS, the City and County of San Francisco is particularly appreciative of this program, having, over the years, invested $400,000,000 in a great water supply system to serve not only ourselves but also our neighbors in adjacent counties; and

WHEREAS, San Francisco is honored by having been selected as the city in which the American Water Works Association will hold its 79th Annual Conference:

Now therefore, I, George Christopher, mayor of the City and County of San Francisco, do hereby proclaim the week of July 13, 1959, as "AMERICAN WATER WORKS WEEK" in San Francisco, and extend a warm and cordial welcome to the representatives of the water works industry who have gathered from throughout the United States, Canada, Mexico, Puerto Rico, and Hawaii, together with sincere wishes that the conference be productive of further advance in this essential field.

At the fifteen technical sessions more and more interested members than ever before attended and participated in the discussions of the problems, projects, and prospects of the public water supply field. And though keynoter became keythroater when Interior Secretary Fred Seaton succumbed to acute laryngitis, his message on "Water—America's No. 1 Problem" was deliv-

(Continued on page 36 P&R)

(Continued from page 35 P&R)

ered by a worthy coInteriorator, Allen Cywin, assistant director of the Office of Saline Water. Other highlights too numerous to mention were included among the 60 formal presentations and the innumerable committee and task group reports that were scheduled. Meanwhile, at every hour of day and night some of AWWA's hundred or more regular committees or its thousands of irregulars were in session,

Convention Management Committee Chairman James H. Turner, general manager of San Francisco's Water Dept., and M. J. Shelton, formerly deputy director of California's Dept. of Water Resources, have a word with coprogrammer AWWA Treasurer Bill Orchard. They, together with Interior Secretary Fred Seaton, spoke on water —America's No. 1 problem.

bringing expert energy to bear upon the problems of the field.

All was not work, of course; there was food, fun, and frivolity as well, beginning on Sunday night when the California Buffet took the crowd to the top of the Whitcomb Hotel for a first look at our favorite city and our favorite conventioneers. On Monday night, the traditional award ceremonies featured AWWA's Men of the Year:

HONORARY MEMBER: F. C. Amsbary Jr., E. S. Chase, M. S. Jones, M. C. Smith.
DIVEN MEDAL: Fred Merryfield.
GOODELL PRIZE: L. R. Howson
DIVISION AWARDS: M. E. Flentje and R. J. Sweitzer (Distribution); A. C. Rener (Management); D. F. Metzler, R. L. Culp, H. A. Stoltenberg, R. L. Woodward, Graham Walton, C. M. Palmer, and F. M. Middleton (Publication); Richard Hazen (Reso
FULLER AWARDS: R. B. Adams, E. len, H. H. Behlmer, G. L. Davis, W. Grayson, J. C. Harding, S. E. Harris, W. A. Healy, H. N. Jernigan, J. P. Kavanagh, J. E. Kleinhenz, G. W. Marx, C. M. Mathews, P. F. Morgan, L. J. Murphy, H. M. Ohland, F. H. Puckhaber, W. T. Randall, P. A. Reynolds, William Schirmer, H. O. Self, H. B. Shaw, C. V. Signor, W. J. Sommers, F. E. Willey.

AWWA's safest utilities of the year, winners of the Wendell R. LaDue Safety Award:

CLASS 1: Jersey Shore Water Company, Jersey Shore, Pa. (E. P. Jones, President).
CLASS 2: Monongahela Valley Water Corp., Elizabeth, Pa. (F. D. Donahue, Manager).
CLASS 3: San Diego, Calif., Water Department (Paul Beerman, Director).

and AWWA's officers of the year, who presided at a reception before the President's Ball at the Gold Room of the Fairmont Hotel. And on Tuesday night Bill Seeger and his boys—John Brucato, Bill Grant, Bill Hays, Earl Jackson, Carl Lauenstein, and George Wehrheim—as the FUN Night crew, put on a show that had everyone, first, tasting at one of the nine tables featuring different California wines and, then, toasting such performers as Miss San Francisco, the Sportsmen, and sundry supervaudevillains, not to mention Hot

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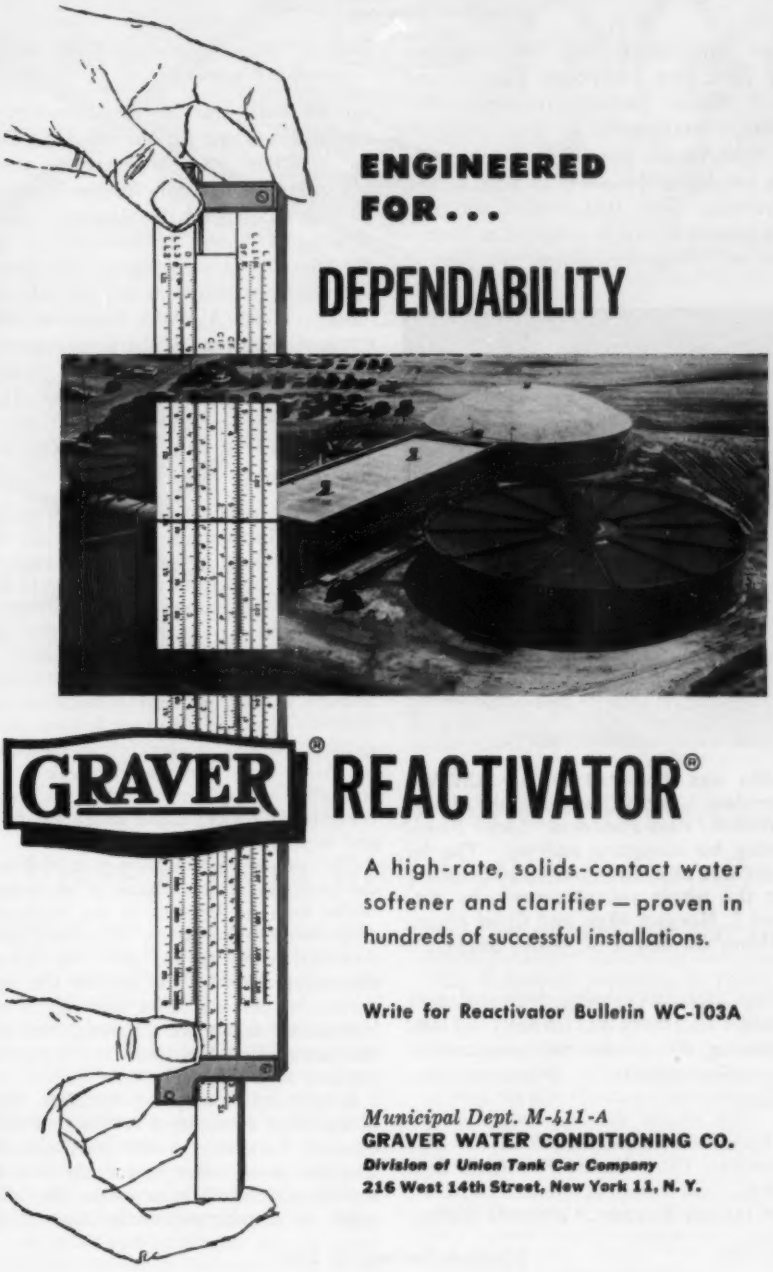

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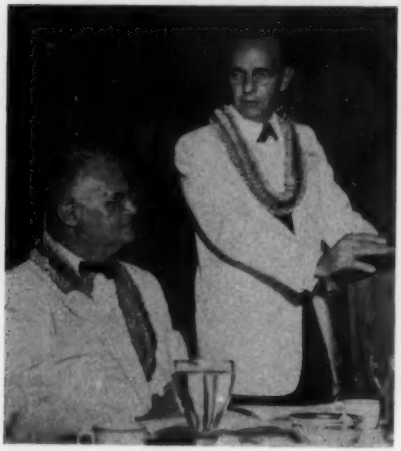
(Continued from page 36 P&R)

Lips Merryfield, Bill the Bagpiper Orchard, Jim Trombone Turner, and Melophluous Lauren Grayson, musicians extraordinary.

With Wednesday night free for seeing or doing the town at will, it was Thursday night that capped not only a convention, but a career, that everyone will long remember, the annual



Aloha was the word as new AWWA President Lauren Grayson spoke of new AWWA Past-President Lew Finch during his inaugural address. The lei motif was provided—not only for them, but the whole record crowd—by Edward J. Morgan, Mgr. and Chief Engr., Honolulu Board of Water Supply.

dinner and dance being dedicated as a "Salute to Harry E. Jordan." Thus, following the traditional presentation of section awards by President Lew Finch:

HILL CUP: California Section

HENSHAW CUP: Pacific Northwest Section

OLD OAKEN BUCKET: California Section

SPECIAL MEMBERSHIP AWARD: Intermountain Section

and the inauguration of Lauren Grayson as President for the coming year, the 1,400 in attendance turned their full attention to "Mr. Water Works" to do him honor for the almost 23 years of accomplishment as Secretary of the Association he will have completed upon his retirement at the end of this month. With AWWA Treasurer Bill Orchard, chairman of the arrangements committee, presiding, and the Jordan children and grandchildren on hand as guests of the committee, the "Salute" was touched off with this "Tribute" by Past-President Abel Wolman:

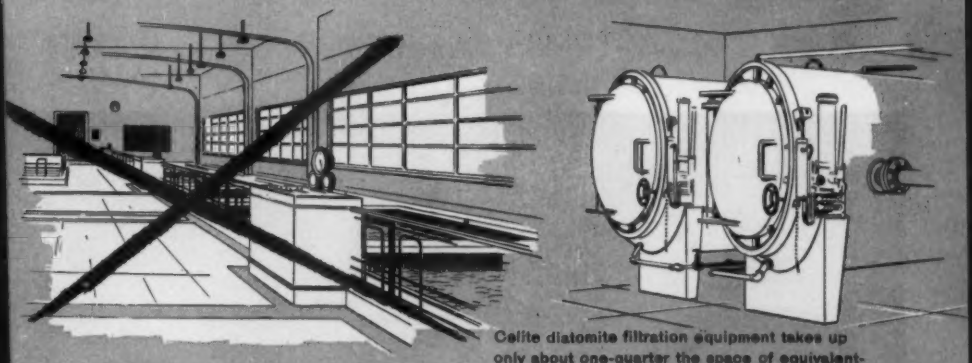
Many in history have debated whether men make institutions, or whether the institution creates the man. In the case of Harry E. Jordan the answer is obvious. A quarter of a century ago, the AWWA was already a veteran in the circle of voluntary professional groups. Into it Jordan brought a vitality of leadership, a scope of purpose, and a depth of responsibility which it had not known prior to his initiation. Today, by any measure, the Association stands at the peak of its strength—in total membership, in technological guidance, in journal superiority, and in public respect.

The single-minded devotion to raising the professional competence of the water works man in America is the hallmark of Jordan's entire career. His entry into Association affairs was early, his scientific preparation for his activity was superior, his personal drive and vitality of interest and action were striking, and his standards of professional and personal conduct were singularly high.

It came as no surprise, therefore, that in assuming direction of AWWA affairs, dynamic leadership would soon prevail. The last quarter of a century fulfilled to the utmost this early promise. In later years, the membership of the Association

(Continued on page 40 P&R)

1. REDUCE FILTER HOUSING SPACE 75%



Celite diatomite filtration equipment takes up only about one-quarter the space of equivalent-capacity sand filter systems.

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Smaller floor space needed for diatomite filtration permits lighter, lower-cost building methods and materials.

You save filtration construction dollars these 2 ways with Celite diatomite

One installation after another proves you need about 75% less filter housing space for equivalent capacity when you use diatomite filtration with Johns-Manville Celite*.

Also, diatomite's lighter, smaller equipment permits you to use lower cost building methods and materials. For example, a simple concrete slab with light framing and siding instead of a large reinforced concrete-and-brick building with built-in concrete filters#.

Diatomite filter equipment is so compact because it provides a much larger filter surface in proportion to size of equipment. In many cases, raw water can be filtered directly—pre-treatment facilities can be eliminated. For Celite removes more suspended solids, including amoebae and algae, and turbidity is usually much lower.

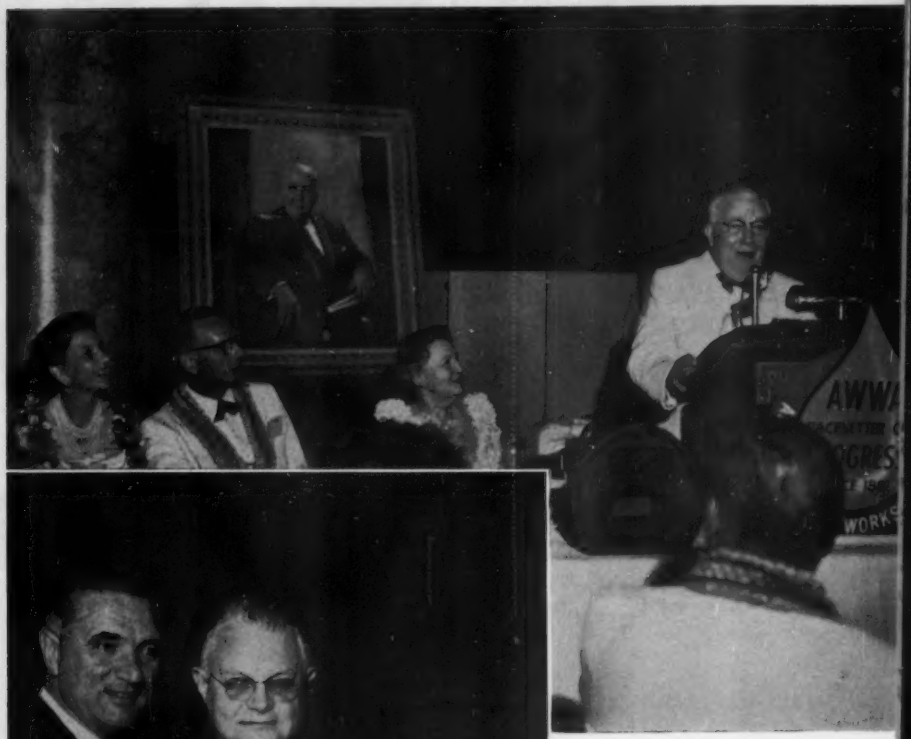
Mined by Johns-Manville from the world's largest and purest commercial diatomite deposit, Celite is carefully processed for purity and uniformity. It is available in a wide range of grades for best practical balance of clarity and flow rate with any suitable filter. For further information, see your nearby Celite engineer. For free technical reprints and illustrated brochure, write to Johns-Manville, Box 14, N.Y. 16, N.Y. In Canada, Port Credit, Ont.

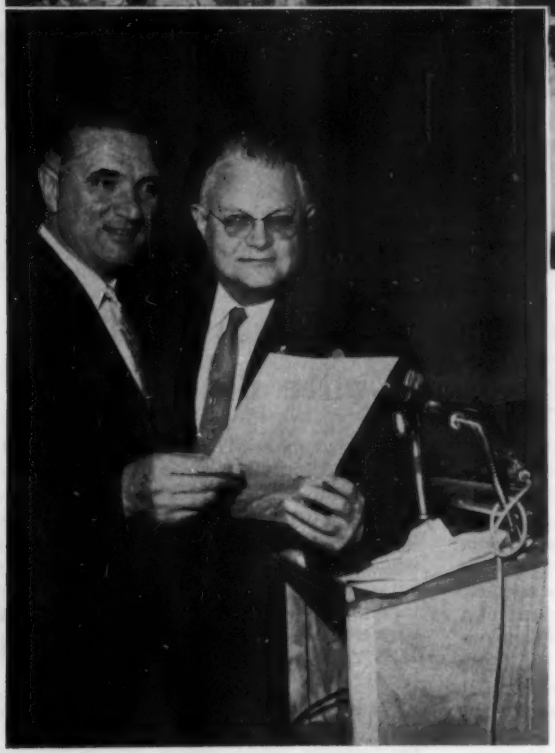
*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

#*See Comparison Studies of Diatomite and Sand Filtration* by G. R. Bell, Journal American Water Works Association, September, 1956 or write for free reprint.

JOHNS-MANVILLE

(Continued from page 38 P&R)





Above, "Mr. Water Works" a knowledges the "Salute." Left right are: Mrs. and Preside Grayson, and Mrs. Jordan su rounded by Mr. Jordans.

At the left, President Lew Fin takes a look at the "Americ Water Works Week" proclam tion held by San Francisc Mayor George Christopher.

(Continued on page 42 P&R)

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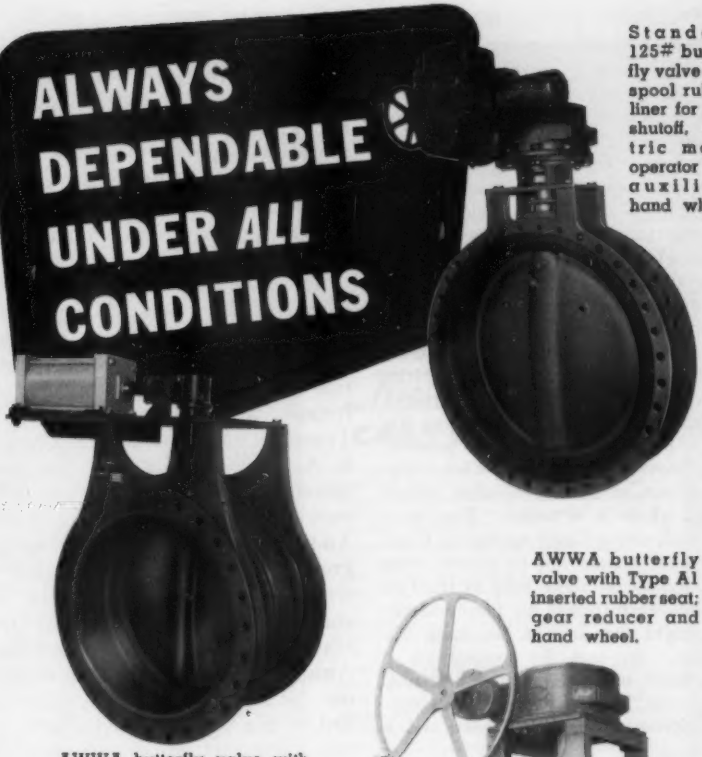

Standard 125# butterfly valve with spool rubber liner for tight shutoff, electric motor operator and auxiliary hand wheel.

AWWA butterfly valve with Type A1 inserted rubber seat; gear reducer and hand wheel.

AWWA butterfly valve with spool rubber liner for tight shutoff; air cylinder operator.

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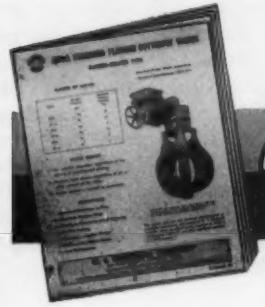

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BUTTERFLY VALVES

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(Continued from page 40 P&R)

was concerned more with slowing down Harry than speeding up the Association. For the latter, progress was and is rapid, and his successor may profit by its acceleration.

Harry would be the first to point out that no professional society rests upon the strength of only one individual, that many have accompanied him with work and counsel on the road of Association growth, and that expansions in professional emphasis have been the products of many minds. It is equally pertinent, however, to point out that every proposal, every idea, each new activity dies at birth, unless a catalyzer seizes and nurtures it to fulfillment by breathing continuing life into it. This catalysis Harry uninterruptedly provided during his official lifetime—without it the Association would not stand where it is today. That it is strong, vital, and militant we owe to him!

The record should not be closed, even temporarily, by reference only to Harry's official life—even though his family sometimes thought that it was becoming his whole life. In fact, he exemplifies a truly "whole" man—a devoted husband, a fond parent, a cherished friend, a cultivated scholar, a touch of a poet, and a gentleman.

He will forgive us if this bare display of his virtues does little justice to his vices and makes him appear a little less than human. Another meeting, less public and more facetious, must be reserved for his minor vices!

Tonight, whether he likes it or not, he must bear the embarrassment of having his innate riches spread before him by his friends, of whom I count myself a fortunate member. Ruth and his children will support the accuracy of our charges!

We wish long life, continued work, more play, and permanent happiness to the midcentury Mr. Water Works, Harry E. Jordan.

In carrying on the "Salute," Past-President Fred Merryfield unveiled an oil portrait of "Mr. Water Works" to be hung first in the Jordan home and then in the offices of the Association, and Vice-President Caesar Wertz gave Mrs. Jordan a personal photograph of it. Three past-presidents from California—George W. Pracy (1933), William W. Hurlbut (1937), and Samuel B. Morris (1944)—then joined in presenting a silver tray containing the signatures of all living past-presidents of the Association. AWWA assistant secretaries Ray Faust and Eric Johnson jointly presented a "Book of Friendship" containing letters of congratulation from officers, directors, and other friends and coworkers. AWWA Transportation Committee Chairman E. A. Sigworth officiated in the presentation of a postconvention trip to Hawaii to "Mr. and Mrs. Water Works." And President Lew Finch, bringing greetings from Mr. Jordan's alma mater, Franklin College, Franklin, Ind., announced the establishment of a Harry E. Jordan Student Achievement Award at Franklin as a perpetual tribute. Altogether it was a salute that, had he not been involved, Harry Jordan might well have pronounced "fit for not merely a king, but a secretary." And the ovation which accompanied it was clearly fit for "Mr. WW" himself.

Looking back at the meeting as a whole next day, after the Board of Directors officially adjourned it, no one could have been more relieved than Jim Turner, local chairman of the Convention Management Committee, and his staff of first lieutenants, George Burr, Joe DeCosta, Ray Hausmann, Earl Jackson, Chris Medbery, Bill Seeger, and Bill Simons. It was they, together with Mrs. George Burr and Mrs. Earl Jackson, cochairmen of the ladies program, who developed both the spirit and the substance of what was in every way and in everyone's way a wonderful meeting.

(Continued on page 44 P&R)

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★ Permanent Bottle-Tight Joints

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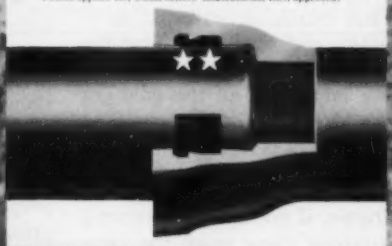
*Patent applied for. Underwriters' Laboratories, Inc., approved.



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(Continued from page 42 P&R)

"Yes, but," says a man we've barely dared mention in this California story. "Yes, but," says Vice President C. F. Wertz from Miami, FLORIDA. "Yes, but," says Veep Caesar—"Wait till next year"—May 15–20 to be specific; Bal Harbour, Fla., to be exact; most important, to be there!

Fast company is what AWWA's new president appears to be keeping these days, with the likes of Charles Starkweather, Ogden Reid, and Ingrid Bergman. That, at any rate, was the lineup of the "People" column in the Jun. 6 edition of Denver's *Rocky Mountain News*. Charlie was newsworthy for his impending execution as a mass killer; Ogden, for his confirmation as ambassador to Israel; Ingrid, for her continued troubles with former husband Roberto Rossellini concerning custody of their children; and Lauren for his address before the General Federation of Women's Clubs in Los Angeles, where he stirred up the gals with the word that "we are not properly equipped to collect, store, process, and transport water in sufficient quantity and quality to meet the needs of our population." And when we say we hope that all the gals got Lauren's address, we don't mean to suggest that it was Charlie, Ogden, and Ingrid who were in fast company.

Fluorinews, if not new fluorecruits, continues strong along much the same pattern as it has for years, but some special items are worth noting:

● Nationally a Roper poll indicated that 53 per cent of the population considers fluoridation beneficial, whereas only 18 per cent regards it as detrimental, the other 29 per cent admitting to complete ignorance of its effects. Despite this, the US Public Health Service reports that the measure is defeated more often than approved in local referendums and that only 32,000,000 people are receiving fluoridated public water supplies, while at least 78,000,000 are not. According to USPHS, defeat of fluoridation locally is the work of three separate groups of opponents:

1. Those who oppose the measure because of personal anxieties aroused.
2. Those who acquire social status, political gain, or personal profit by opposing it.
3. Those who are fearful of change and suspicious of authority.

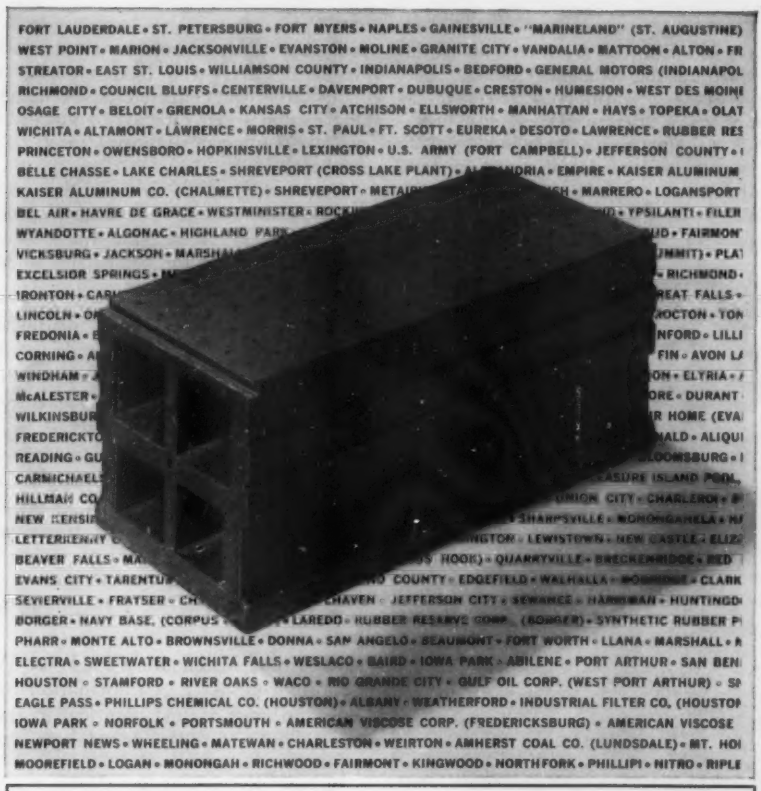
Meanwhile, on the effects of fluoridation, *Nutrition Reviews*, official journal of the Nutrition Foundation, has published a series of reviews of recent pioneer post-mortem studies indicating that no significant differences were found in the bones and tissues of persons who had ingested fluoridated water for from 10 to 76 yr and others who had lived in nonfluoride areas for similar periods.

● In New York, State Health Commissioner Herman E. Hilleboe released an engineering report on fluoridation practices in twenty large cities which indicated that the procedure can be accomplished safely, effectively, and inexpensively in large-city water systems. A condensation of the report, prepared by Professor William T. Ingram of New York University's College of Engineering, who directed the study, is scheduled to be published in the September issue of the JOURNAL.

● In Indiana, AWWA's local section received this resolution of commendation from the Indiana State Dental Assn.:

WHEREAS, dental decay is the most widespread disease affecting mankind and

(Continued on page 46 P&R)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GLAZED TILE FILTER BOTTOMS

(*Continued from page 44 P&R*)

results in a financial drain on both the individual and the community, and

WHEREAS, scientific research over the past 50 years has proved communal fluoridation an effective and safe public health measure to reduce dental decay by two-thirds, and

WHEREAS, today two out of every three citizens in Indiana served by a public water supply are receiving the benefits of the proper amount of fluorides, and

Indiana Section Chairman Harvey Wilke displays a plaque presented to the Section by the Indiana State Dental Assn. in recognition of the achievement of Indiana water utilities in providing fluoridation when called upon to do so.

WHEREAS, the efficacy of this preventive public health measure is contingent upon continued sympathetic and dependable action by water works designers, administrators, and operators, therefore be it

Resolved, that the Indiana State Dental Assn. recognize the Indiana Section of the American Water Works Assn. as representing those members of the water works industry who have accepted responsibility in effectuating communal fluoridation when directed to proceed by proper municipal authority, and be it further

Resolved, that the Indiana Section be thus commended for continued faithful services in providing safe water of accepted quality for the health and welfare of the citizens of Indiana.

● From New Jersey, meanwhile, came the report that only 45 of the state's 567 communities received water with the optimum fluoride content —and only 34 of these, served by 10 utilities, had artificially fluoridated supplies. In Newark, where water fluoridation was rejected in favor of providing free fluoride pills for those who wanted them, the city authorities reported that only 4,500 of the 96,500 pills it had purchased 3 years ago had been distributed.

● From Michigan, a study at Wyandotte after 8 yr of fluoridation indicates findings almost identical to those of Grand Rapids, Newburgh, and Brantford.

● Finally, in California in April, the Public Health Committee of the State Assembly overwhelmingly voted down a proposal to ban the use of fluorides in California water supplies, despite warnings that it was, thereby, furthering totalitarian philosophy.

● But perhaps the most significant news should be the continued nonappearance of the long predicted mental and physical fluoridisaster.

H. C. Brown has retired as vice-president of Chicago Bridge & Iron Co., New York, after more than 43 years with the firm. He will remain on the board of directors.

(*Continued on page 48 P&R*)

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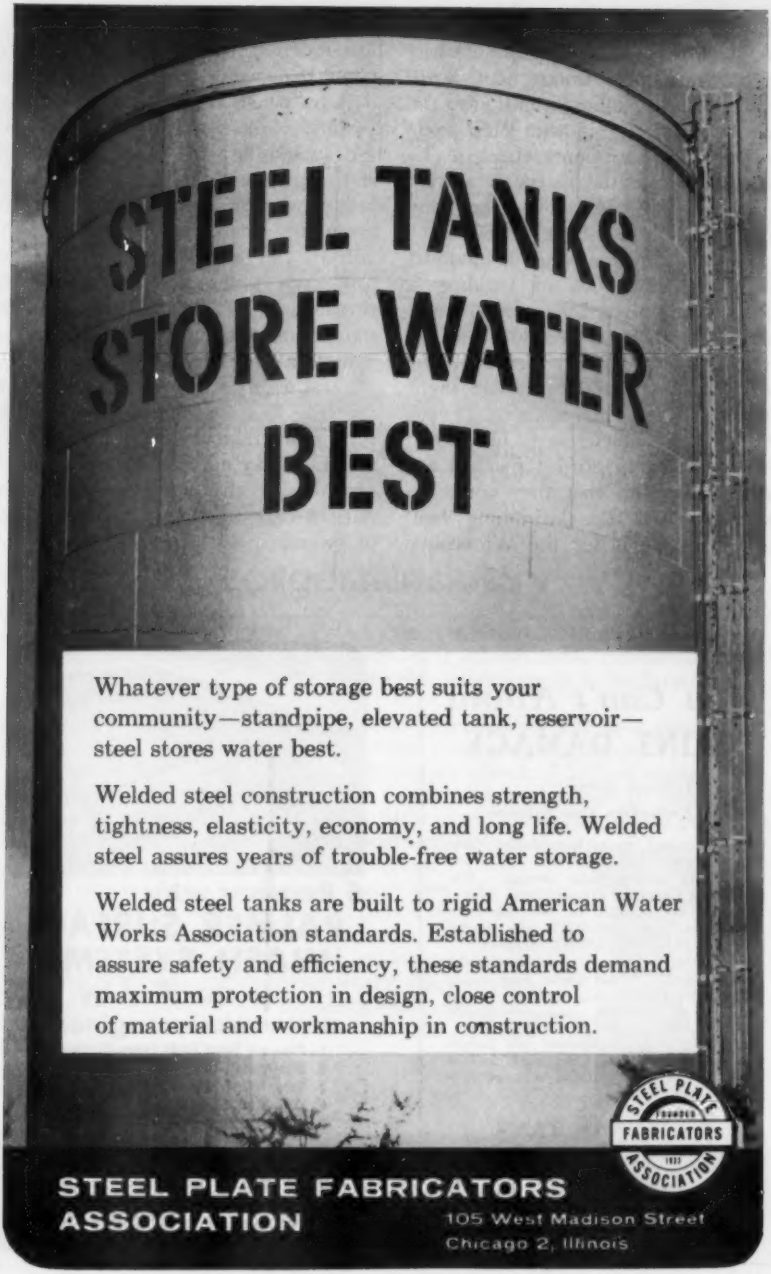
(*Continued from page 46 P&R*)

Old wives' tales, to which we have always considered ourself relatively immune, particularly as they related to water supply, have suddenly caught us napping again. No, we haven't taken to believing that when lightning grounds itself in or near a well it spoils the water therein. Nor have we been convinced that water cannot extinguish a fire caused by lightning. But, by gum, we did believe—with a lot of our friends and experts—that the best way to water a lawn was to soak it thoroughly once a week and that light watering just watered the weeds and left the grass to thirst. So now, when the agricultural research station at Fort Collins, Colo., on the basis of a 5-yr study, tells us that *light watering, done frequently, is by far the best,* that even a little water will do good, that keeping the first ½ in. of soil from drying out is the answer to proper watering, we begin to wonder. Can it be that old wives' tales squeezed into shape by elastic logic and dressed up in impressive scientific terminology are as deceptive these days as old wives themselves?

At any rate, look to your lawn booklets, men, lest your own old-wifery show!

Lawson D. Matter has retired as chief of the Water Supply Section, Pennsylvania Health Dept., after 40 years of service with the department. Long active in AWWA affairs (he is presently director from the Pennsylvania Section), Mr. Matter holds the Fuller Award in recognition of his distinguished service to the field, which was also the subject of a resolution passed at the Pennsylvania Section meeting in June.

(*Continued on page 50 P&R*)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(*Continued from page 48 P&R*)

A bad turn for the Boy Scouts was the action of the Connecticut State Health Dept. in calling attention to the ban on swimming in the West Side Pond at Goshen, Conn., because its waters flow into the reservoir system of Waterbury. Actually, the Boy Scout Council had bought 180 acres of property on the pond 18 months before with the idea of building a $150,000 camp there for swimming and other water sports. For 50 years the waters of the pond had been used for swimming by residents of its eight waterside cottages and a few other visitors without interference, but when word of the camp project reached authorities they felt that they could no longer overlook the swimming ban. The alternative is for the Waterbury water department to build a treatment plant that would cost several million dollars, which it may very well have to do if a bill exempting the pond from the swimming rule gets through the state legislature this year again. Last year Governor Ribicoff vetoed the bill, grounding the 1,500 Boy Scouts involved, but this year, with Goshen property owners concerned at the threatened loss in values, with the tourist business concerned over a precedent that will eventually plague them all, and with contributors of $60,000 to the Boy Scout purchase and building fund more than a little interested, the situation may not be the same. It will probably be the Governor again who must decide whether it is to be drink or swim!

(*Continued on page 98 P&R*)

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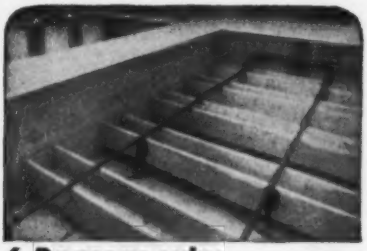

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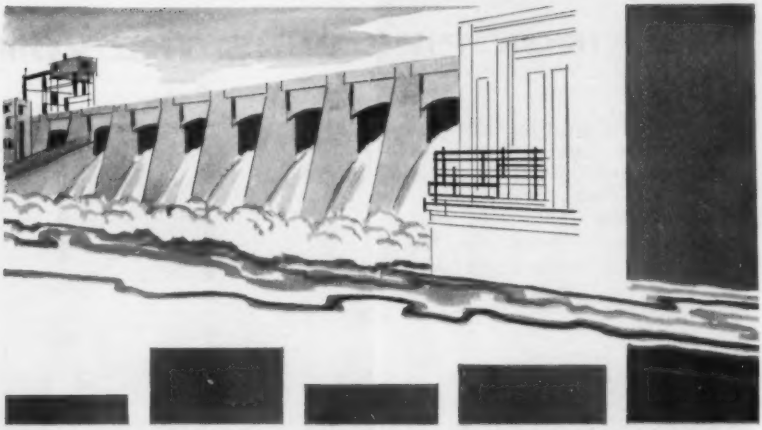

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Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

HEALTH AND HYGIENE

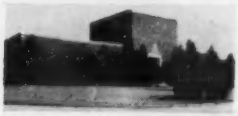
A Contribution to the Contamination of Drinking Water by Artificial Manure and the Damage to Health it Implies. R. SCHULZ. Deut. Gesundheitsw. (Berlin), 11: 40:1357 ('56). Chem. examn. of no. of wells showed that water contained quant. of nitrates, nitrites, sulfates, and chlorides, originating from artificial manure (Kainit and calcium-ammonsalpetre) stocked for yrs at distance as great as 100 m (328 ft) from wells. Shallow stone wells were found to be most contamd., probably because masonry had become affected by sulfates. Increased frequency of gastrointestinal disturbances among users of wells is ascribed to chem. contamn. Possibly also high potassium content of water (from Kainit) might do harm. Further observations in this field are required; it may be necessary to prohibit outdoor storage of artificial manure.—*PHEA*

Potential Injection From the Drinking Fountain. W. L. MALLMANN & A. K. FONTES. AMA Arch. Ind. Health, 16:77 ('57). This paper first sets out acct. of information already in existence regarding potential infection from drinking fountains. Possibility of transfer of bacteria by splashing water led to this investigation into role of aerosols in connection with drinking fountain sanitation. When bacteria fall in drops of liquid onto hard surface they are disseminated by aerosols which remain in suspension for considerable period of time. 4 types of fountain were examd. in this survey: bubble fountains, vertical jet types, and 2 angle jet types, with and without orifice guards. Data presented show that aerosols are formed as result of splashing of water in bowl of fountain. When source of bacteria is present, as it is when person drinks, these aerosols become heavily contamd. Agar plates held 1 and 2 in. above stream of water developed so many colonies that estn. was impossible. Fountain of most up-to-date pattern with shielded angle jet was sterilized, but nos. of streptococci were demonstrated on orifice within 30 min of fountain being used by 1 person only. Aerosol contamn. of drinking fountains may be important factor in spread of naso-pharyngeal infections among groups of people in factories, offices, schools, canteens, etc. It is considered that trouble may be overcome by modification in drinking fountain design and servicing, procedure which would seem worthwhile to industrial hygienists in order to reduce sickness absenteeism from minor ailments.—*BH*

Disturbances of Health, Particularly in Infants, Due to Nitrates in Drinking Water. Consideration of Local Hygienic Conditions. K. HORN. Stadtehyg., 9:2:21 ('58). In last few months 3 cases of methaemoglobinaemia in infants occurred in different parts of Saxony. This experience led to inquiry reported in this paper, which also discusses toxicity of nitrates in relation to relevant literature. Some particulars of these 3 cases, 1 of which was fatal, are given and are similar to those previously reported. Considerable no. of analyses of well waters in districts concerned were carried out and tables give findings of these in respect of amts. of ammonia, nitrite, nitrate, organic matter, and chlorides and bacterial counts and *coli* titers. Nitrate content (as N_2O_5) of 3 waters used for prepn. of feeds of these 3 infants were 976, 89, and 153.8 mg/l. Many other wells were found to yield water with high nitrate content and other evidence of pollution. In summary, it was found that more than 80% of rural water supplies from 12 districts in Saxony had a nitrate content of more than 30 mg/l. Nitrate poisoning in infants is not detd. only by presence of nitrate in drinking water, but other causes

(*Continued on page 64 P&R*)

FLUIDICS AT WORK



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(*Continued from page 62 P&R*)

which bring about bact. formation of nitrite in digestive tract result in methaemoglobin production. Hygienic importance of anal. findings is discussed.—*BH*

Nitrates in Drinking Water. L. Terhaag & H. Eyer. Offentl. Gesundheitsdienst. (Ger.), **20**:1:1 ('58). This paper contains mainly a review of literature on nitrates in drinking water as a cause of mathaemoglobinaemia in infants. Particular attention was first drawn to danger of a high nitrate content in drinking water in 1945 in a paper from the USA although reference had been made to this danger some years before. In Germany poisoning by nitrate was first noted in 1947 among cattle, and cases of methaemoglobinaemia in infants were first described in 1953. Clinical features of poisoning and present views on toxic concn. of nitrate and conditions under which nitrate is reduced to nitrite in some artificially-fed babies are described and discussed. Prevention of nitrate poisoning is considered, with stress on the importance of advising mothers living in areas where nitrate content of water is high to make up feeds for their babies with distd. water.—*BH*

Water: The Public Health Inspector's Responsibilities and Problems. R. Emerson. Sanitarian (Gr. Br.), **65**:502 ('57). List of diseases which may be transmitted by contamd. water supplies and swimming baths is given. Bact. examn., phys. and chem. anal. of water, and min. acceptable standards for water supplies are described. Responsibilities of public health inspector in maintaining satisfactory urban, industrial, and rural water supplies; rain water supplies; and swimming baths are discussed.—*WPA*

Hygiene of Baths in Relation to Modern Customs Such as Sports and Touring. F. Lentze. Offentl. Gesundheitsdienst. (Ger.), **18**:11:455 ('57). Author describes and discusses his views on what should be modern approach to hygiene of open-air and other bathing places. In Germany before 1918 all bathing in open air was understood to be forbidden except in such places where it was specifically permitted. Nowadays bathing in the open is everywhere permitted except where it is expressly forbidden. Possible dangers of infection of many kinds through bathing in pold. waters are classified and discussed. Reference is made to study by Stevenson in US on an extensive enquiry into amt. of infection that may be attributed to bathing. In general, however, opinion is that because bathing in open is now a social custom which is likely to extend, no attempt should be made to forbid it. Information should continue to be sought on magnitude of infection problem, but it seems clear that complete prevention of infection cannot be brought about by official action. Chlorination is not a complete safeguard as a disinfectant of pollutants which have gained entrance to water. Of great importance is to lessen extent of such poln. by securing a higher personal and general standard of hygiene among persons who camp near bathing sites, by improving local methods of disposing of excretal refuse and by careful attention to the wholesomeness of bathing place and its surroundings.—*BH*

Bacteriological Aspects of the Hygiene of Bathing Beaches. J. Brisou. Tech. Sanit. Munic., **49**:167 ('54). Author reviews work of various investigators on viability of pathogenic bacteria in sea water at bathing beaches, particularly in France, and in edible shellfish.

(*Continued on page 66 P&R*)

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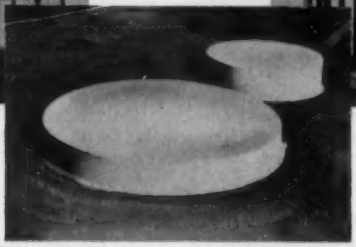

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(*Continued from page 64 P&R*)

Some of diseases contracted by humans as a result of poln. of shellfish, sea water, and beaches are enumerated, and general methods by which disease can be prevented are given.—*WPA*

Mineral Constituents of Bihar Water. III. Waters of Some Goitrous Areas of Bihar. S. P. Roychowdhury & B. P. Gyani. Indian J. Appl. Chem., **21**:41 ('58). Goiter is not caused by low I content by itself or high F content by itself. Analyses are reported for a large number of wells. —*CA*

Minamata Disease; An Unusual Neurological Disorder Caused by Contaminated Fish. D. McAlpine & S. Araki. Lancet, 629 (Sep. 20, '58). Minamata is a small industrial town near southwest coast of Kyushu, most southerly of main Japanese islands. Chief factory makes artificial fertilizers and its effluent empties into Minamata Bay. Mysterious nervous illness—Minamata disease—began to affect villagers near bay at end of 1953 and by 1956 had reached epidemic proportions. During 1956, 15 patients (9 adults and 6 children) were admitted to Kumamoto Univ. Hospital for illness of acute or subacute onset in which numbness developed in extremities, accompanied or followed by slurred speech and unsteady gait with increasing disability. Most of patients complained of deafness and disturbance of vision. Other signs and symptoms which occurred in some patients were dysphagia, insomnia, emotional disturbance, confusion, drowsiness, and stupor alternating with periods of restlessness. Cerebellar ataxia and dysarthria were always present. Choreiform or athetotic movements were observed in several adults. Most severely affected patients died, and others remained incapacitated in varying degrees. Improvement in hospital was sometimes followed by relapse on return home. Main post mortem findings were in the central nervous system—cell degeneration was most marked in granular layer of cerebellum, but was also found in basal ganglia, hypothalamus, midbrain, and cortex. Public health department of the university reported 52 cases of disease (17 deaths) and a morbidity rate of 19 per 1,000 in a particular group of 4 villages. All patients frequently ate fish caught in bay. Since Nov. 1956, when fishing in bay was prohibited, no fresh case of disease has been reported. A nervous disease also occurred in animals and in 1 example it is stated that in 1953–'56, out of a total of 61 domestic cats, 50 had died. Chem. investigations which were carried out showed that: [1] some fish and shellfish from bay had increased amts. of manganese, selenium, and copper; [2] silt from that part of bay which received factory effluent contained sulfur, mercaptan, and large amts. of selenium; [3] selenium was found in human and cat livers in an amt. equal to that found in cases of selenium intoxication; and [4] raw materials used in the factory contained *inter alia* thallium and selenium. These results are difficult to evaluate but evidence so far points to toxic action of some inorganic chemical compound in factory effluent.—*BH*

Evaluation of the Safety of Water and Shellfish in France. R. Ladouce. Tech. Sanit. Munic., **49**:175 ('54). A detailed description is given of a new method used in France by *l'Institut Scientifique et Technique des Pêches Maritimes* to ensure that oysters and other shellfish are safe for human consumption. It was found that in method formerly used, growth of some harmful organisms was inhibited when indole was used. New method, which has been found to be satisfactory, involves use of phenol peptone broth, and cultures are incubated at 42°C.—*WPA*

The Water Factor in the Epidemiology of Dysentery. J. Kratochvil & M. Tarabcak. Ceskoslov Epidemiol., Mikrobiol., Imunol. (Prague), **7**:271 ('58). In '55 an epidemic of dysentery occurred in 3 population groups living in temporary housing in a camp at Kosice (Czech.), with an incidence of 43.8%, 50.6%, and 47% in the 3 groups respectively. *Shigella flexneri 2* was isolated from stools of patients and from water of a well which supplied camp. In a lab. investigation of persistence of dysentery bacilli in water, *Sh. flexneri* and *Sh. boydii* survived for 52 days and *Sh. sonnei* for up to 105 days at room temperature.—*BH*

Cadmium Administered in Drinking Water to Rats. L. E. Decker et al. AMA Archiv. Ind. Health, **18**:228 ('58). Five groups of rats were given water containing between 0.1 and 10.0 ppm cadmium for 1

(*Continued on page 70 P&R*)

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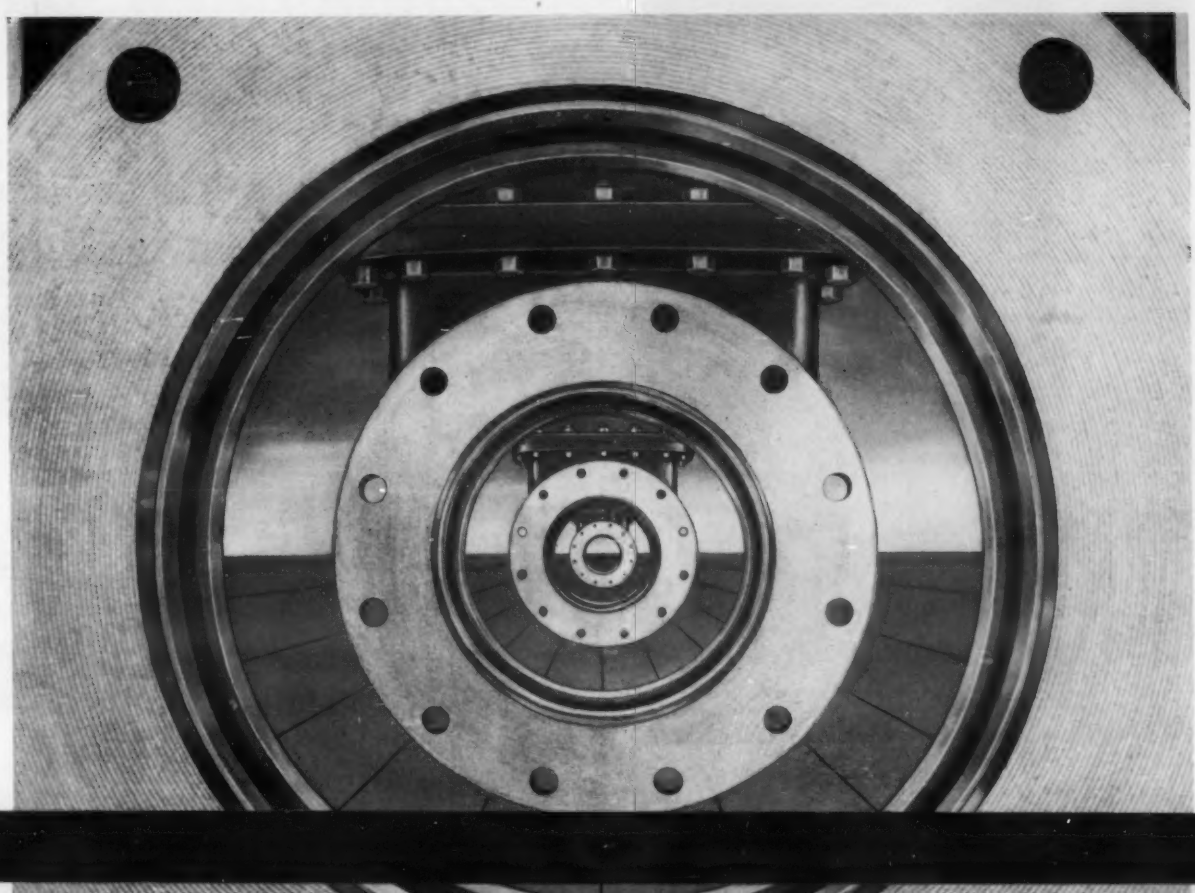

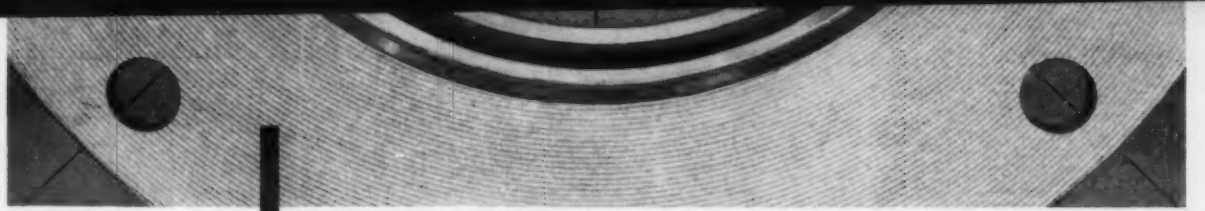

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(Continued from page 66 P&R)

year. No differences between these groups and controls were observed in water intake, food consumption, or body weight, nor were any pathological changes in blood or other tissues noted. Cadmium content of either liver or kidney increased in direct proportion to cadmium intake. Tissue values obtained at end of 1 year's ingestion were roughly double those obtained at end of 6 months. Kidneys retained 2–3 times amt. of cadmium retained by liver when calculated as micrograms of cadmium per gram of fresh tissue. A reduction in growth rate, water consumption, and blood hemoglobin was found in rats ingesting 50 ppm cadmium for 3 months. Bleaching of incisors was also observed in these animals.—*PHEA*

DISINFECTION

Effect of Chlorinated Water, Calcium Hypochlorite, Chloramine, and Iodine on the Vitality of *Endamoeba dysenteriae*. I. SIMITCH ET AL. Arch. inst. Pasteur Algerie (Algiers), **34**:205 ('56). Suspensions of feces contg. *Endamoeba dysenteriae* were dild. in distd. or tap water and treated with iodine, chlorinated water, calcium hypochlorite, or combined chlorine, and cysts were counted. Calcium hypochlorite gave safest amebicidal effect.—*WPA*

Inactivation of Spores of *Bacillus globigii* and *Bacillus anthracis* by Free Available Chlorine. A. R. BRAZIS ET AL. Appl. Microbiol., **6**:338 ('58). Spores of *Bacillus globigii* (*Bacillus subtilis* morphotype *globigii*) and *Bacillus anthracis* were exposed to sporicidal free available chlorine (FAC) during contact periods of 2 and 48 hr at hydrogen ion concns. of 6.2, 7.2, 8.6, and 10.5. As pH increased from 6.2 to 10.5 at 22°C, amt. of FAC required to produce a 99.99% kill of *B. globigii* spores in 90 min increased from 1.9 mg/l to more than 450 mg/l. When exposure time was increased from 2 to 48 hr concns. of FAC required to produce a 99.99% kill of spore suspensions were decreased. 3–4 times as much FAC

(Continued on page 72 P&R)

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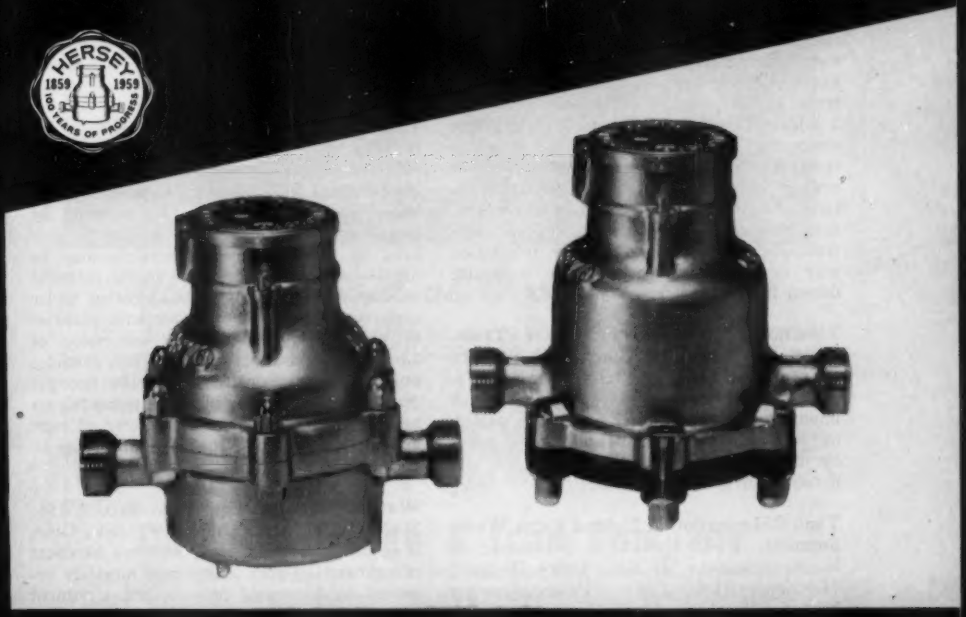

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(*Continued from page 70 P&R*)

was required to produce 99.99% kill of spore suspensions at 4°C as at 22°C when other environmental conditions were held constant. FAC was much more sporicidal for *B. anthracis* spores than for *B. globigii* spores, except at pH higher than 9.5. When amt. of FAC used in observations was expressed in terms of hypochlorous acid, it was found that approx. same concn. of HOCl was required at all pH levels at 22°C to achieve a 99.99% kill.—*PHEA*

Living Organisms in Public Water Mains. K. M. Hart. Inst. Munic. Engrs., **83**:324 ('57). Author describes an instance of occurrence of *Nais*, a small nematode, *Cyclops*, *Daphnia*, and *Asellus aquaticus* in water mains and methods adopted for their elimination. Chlorine was chosen for destruction of all except *Asellus*. To obtain the necessary concn. of chlorine in outlying sections of system, a soln. contg. at least 100 ppm was introduced into branch mains. *Asellus aquaticus* was removed by passing a soln. contg. 0.01 ppm pyrethrum into infected trunk main, with object of paralyzing organisms so that they could be flushed from main. Treatment was continued for 4 days and nos. of live and dead *Asellus* collected each day on traps set at terminal points are shown in a table. Brief description of each of these organisms is given. Various ways in which creatures might enter water supply system are considered and precautions to prevent future infestation are listed. It is pointed out that both *Asellus aquaticus* and *Nais* cling tenaciously to main, and heavy infestation may occur before they appear in water drawn from consumer's tap.—*WPA*

Flotation Techniques in Water Treatment. T. Okura; K. Goto; & H. Suzuki. Kogyo Kagaku Zasshi (Jap.), **60**:373 ('57). Al was electrolyzed in a vessel, through which impure water (SiO_2 14–17 ppm) was passed, to make clear water (SiO_2 approx. 1–6 ppm) by use of coagulation effect of Al ion and flotation effect of foams.—*CA*

Tank Chlorination of Upland Farm Water Supplies. D. L. Bowen; L. F. Battle; & S. B. Thomas. J. Soc. Dairy Technol. (London), **11**:85 ('58). Paper discusses bact. results obtained over 3-yr period with simple, practical method of tank chlorination on 15 dairy farms in Denbighshire (Wales). Source of water for these farms was from mountain streams in limestone area or from shallow springs. Results of investigation indicate that where farm uses pold. water supply and no alternative source is available, adoption of hand chlorination can be recommended for water used for dairy purposes. Success is dependent on maintg. correct hypochlorite dosage in tank at least 6 hr before use. Report points out this should be considered only temporary system.—*PHEA*

On the Behavior of Humic Material in Water. III. The Role of Clay. G. Vanbeneden. Centre Belge Etude et Document. Eaux (Belg.), **39**:35 ('58). Role of humic materials in sedimentation of different kinds of clays has been studied. This is important in knowledge of silt deposits in lakes, reservoirs, canals, and streams. It is often necessary to treat these waters because of presence of large amts. of humic iron and humic matter. Filters may be obstructed prematurely and anion exchangers may retain humic matter so strongly that they cannot be regenerated. If mechanical action due to erosion can alone explain carriage of suspended clay, presence of humic material contributes to accentuating of phenomenon. Study is restricted to region Hautes Fagnes because it is example which is very easy to follow. Composition of different clays and quaternary sands have been studied with reference to adsorption of humic matter. Clays can be peptized by humic matter. Waters which may be colored by loads of humic materials may be decolorized by adsorption of humic material on clay particles. It can be said that under such circumstances humic particles dissolve or peptize clay. Though a succession of adsorption and desorption of clay particles on humic materials, these may be brought down to slow flowing parts of watercourses and deposited as sludges in water storage areas, thus building up bottom sludge.—*PHEA*

Water Softening. Eng. News-Record, **156**: 21:24 ('56). Water supply of Toledo, Ohio, is obtained from L. Erie, and has hardness of approx. 180 ppm. This was formerly removed by lime-soda process, but treatment has had to be suspended owing to formation of tastes and odors. These resulted from discharge of trade wastes into streams run-

(*Continued on page 74 P&R*)

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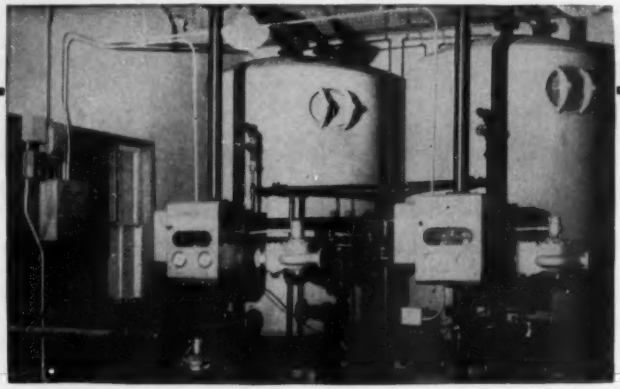
(*Continued from page 72 P&R*)

ning into L. Erie, and from presence of high concns. of algae. They were removed by treatment with activated carbon, but it was found that softening process, which has been in operation since October 1954, lowered pH of water to such an extent that treatment was rendered ineffective. Further work is being carried out on problem.—*WPA*

Effect of Chlorine in Water on Enteric Viruses. S. KELLY & W. W. SANDERSON. Am. J. Public Health, **48**:1323 ('58). Inactivation of enteroviruses by chlorine was investigated by using partially purified viruses and water rendered free from chlorine demand. It was found that usual conditions for disinfection of water supplies were inadequate to kill enteric viruses completely. Thus concn. of free residual chlorine of 0.2–0.3 ppm at pH 7 required contact period of at least 30 min to give complete inactivation. Different virus strains were inactivated at markedly different rates. 2 recently isolated Type 1 polio viruses were inactivated at much slower rate than stock Mahoney Type 1 strain; Coxsackie B1 virus and polio virus Type 3 Saukett strain were inactivated at same rate as newly isolated Type 1 polio virus. On other hand, Mahoney strain of Type 1 polio virus and Coxsackie B5 virus were inactivated considerably more quickly. It was thought possible that variations in sensitivity to chlorine of different strains of virus might be due to presence of some resistant particles in strains that had not been passed frequently in tissue culture. Effects of pH level, concn. of residual chlorine and temp. on time required to kill 99.7% of virus strains were estd. A rise in pH above 6 caused a delay in inactivation time which was much more noticeable at 4°C than at room temp. and with more slowly inactivated virus strains. It is concluded that for inactivation of enteric viruses in water, pH 7 at 25°C requires a minimum free residual chlorine concn. of 0.3 ppm acting for at least 30 min. At higher pH levels or lower temps., more intensive chlorination is required.—*BH*

(*Continued on page 76 P&R*)



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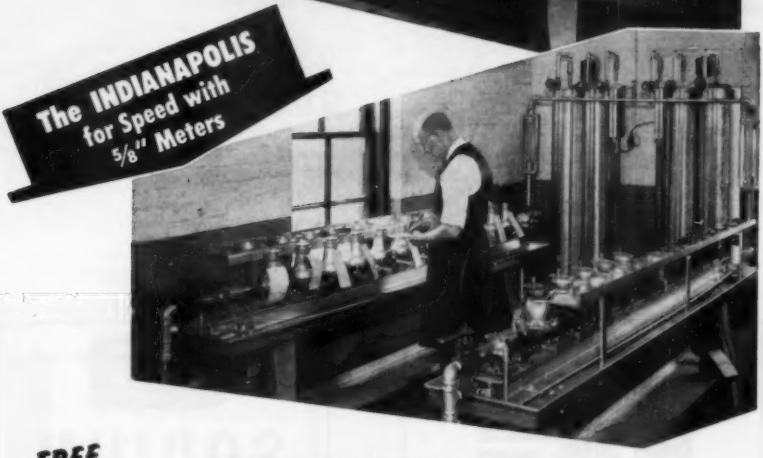

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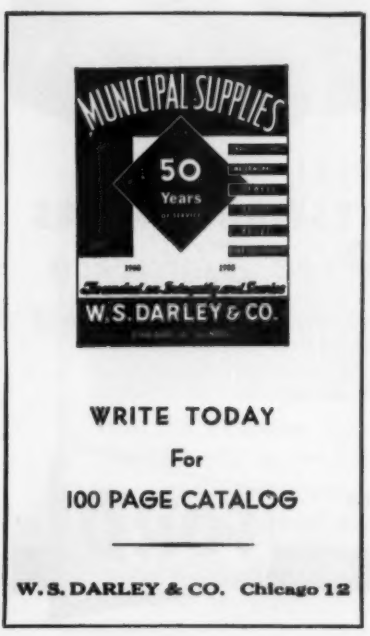
(*Continued from page 74 P&R*)

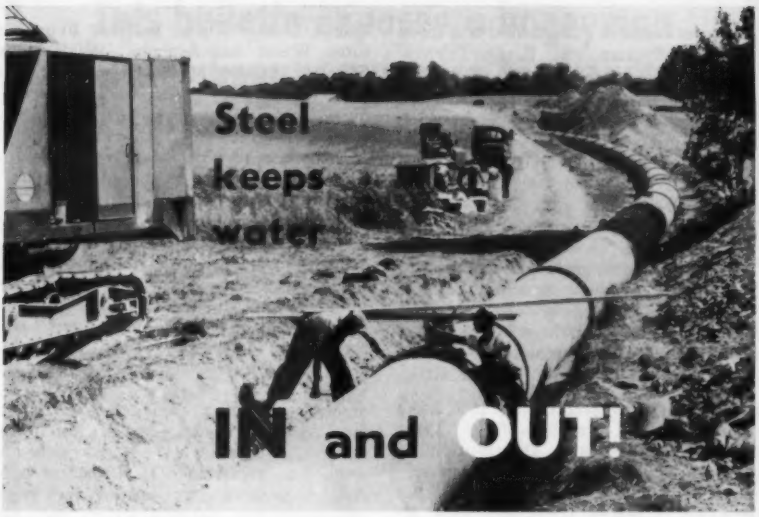
AQUATIC ORGANISMS

The Toxicity of Metal Ions to Aquatic Organisms. W. H. R. SHAW & B. GRUSHKIN. Arch. Biochem. Biophys., **67**:447 ('57). Exptl. results and data collected from literature on toxicity of cations to aquatic organisms are presented. Findings are analyzed in terms of model based on inhibited Michaelis-Menten mechanism and on assumption that cations considered are toxic because they combine with an essential sulfhydryl group attached to key enzyme.—*WPA*

Survival of Rainbow Trout and Perch at Various Concentrations of Dissolved Oxygen and Carbon Dioxide. J. S. ALABASTER; D. W. M. HERBERT; & J. HEMENS. Ann. Appl. Biol., **45**:177 ('57). Authors describe expts. carried out to test relative importance of DO and dissolved carbon dioxide in detg. lethal effect of an environment for rainbow trout (*Salmo gairdnerii*) and perch (*Perca fluviatilus*). The exptl. procedure is outlined and results, given in tables and graphs, are discussed. All expts. were carried out for 24-hr periods. It was found that concns. of carbon dioxide which may occur in pold. streams can increase min. concn. of DO needed for survival of rainbow trout for 24 hr by more than 100%. Increases in temp. between 12.5° and 19.5°C shorten survival period in water contg. up to 67 ppm carbon dioxide. In water contg. more than 59 ppm carbon dioxide, perch are more resistant than rainbow trout to lower lethal concns. of DO, but are less resistant in higher lethal oxygen concn. ranges. Relation between carbon dioxide concn. and oxygen tension at which rainbow trout blood is half saturated with oxygen was found to be similar to relation between carbon dioxide concn. and oxygen tension at which the median period of survival of this species is 1 hr. —*WPA*

(*Continued on page 78 P&R*)





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(Continued from page 76 P&R)

***Asellus aquaticus* in a Public Water Supply Distribution System.** M. E. D. TURNER. Proc. Soc. Water Treatment Examn., **5**:67 ('56). Work is described on methods used in elimg. crustacean *Asellus aquaticus* which had heavily injected all parts of water distr. system. After much searching for method to use to rid mains and laterals of *Aselli* it was decided to use soln. of pyrethrum extract. After considerable lab. and pilot plant work it was decided to use soln. of 0.005 ppm of pyrethrum. This method of elimg. *Aselli* from distr. system proved to be very efficient, except in dead-end mains and service connections where longer period of flushing would have been needed.—*PHEA*

Limnological Investigations in Lake Walchen in the Years 1950–56. I. Temperature, Visibility, and Distribution of Plankton. O. SCHINDLER. Arch. Fisch. Wiss., (Ger.), **7**:162 ('56). Since 1924 construction of power works and other alterations have changed amt. and position of discharges into L. Walchen. Limnological investigations made between 1950 and 1956 are described and compared with investigations made between 1920 and 1923. First part of report deals with results of investigations of temp. conditions, turbidity and distribution of plankton in water from surface to depth of 40 m. Little change was found in temp. or plankton distribution, but visibility was reduced by turbidity caused by fine inorganic particles.—*WPA*

Effect of Pollution on Marine Life. D. J. REISH. Ind. Wastes, **2**:114 ('57). Because of dredging of part of Los Angeles Harbor, an opportunity was provided to measure time required for the biol. degradation of a new substrate. No. of animal species found in bottom mud is used as parameter of pollution. Before dredging, area was biologically unproductive. After dredging nos. of different species increased; 10 species were found at 6 stations in Jan. 1954. In Jun. 1954, 9 species were found. By Nov. of 1954 only 5 species were found and by Dec. of 1955 only 2 species were found. An equilibrium condition was reached about 1 year after dredging. *Capitella capitata*, an annelid characteristic of poln. was relatively abundant. —*PHEA*

Check List of Fungi Isolated From Polluted Water and Sewage. W. B. COOKE. Sydowia, Annales Mycologici, Ser. II. **Beiheft I**, 146 ('57). List of 139 species of mold fungi isolated from sewage and pold. water is presented. Sources of samples from which these fungi were isolated include: Lytle Creek, Ohio, 32 samples in each of 12 consecutive monthly visits; Dayton, Ohio, sew. treatment plant, 15 sites sampled on 16 occasions throughout year; Yellow Springs, Ohio, sew. treatment plant, 5 sets from 9 sample sites; and miscellaneous samples from tributary of Tanner's Creek, Ind.; Ithaca, N. Y.; Glendale, and Cincinnati, Ohio; and several small Ohio creeks carrying relatively clean water and acid mine wastes. A set of terms is introduced to describe relation of each fungus to its habitat. *Lymaphobes* were not present in pold. samples, *Lymaxenes* were present only occasionally as represented by infrequent occurrence in isolations, *Lymaphiles* were present comonly in sew. and pold. waters, and *Lymabionts* have never been found in other habitats than sew. and pold. water. Species are listed alphabetically within structure of std. mycological systematics. Distribution of each species is given according to particular source from which it was isolated.—*PHEA*

Fungi, Bacteria, and Algae of Polluted Waters. A. WURTZ. Bul. Francais de Pisciculture, **182**:5 ('56). Author gives factual evidence to destroy the myth that *Sphaerotilus* can develop spontaneously in a river which is unpold. It and *Leptomitus* cannot develop without source of organic poln. Pollutant materials required for their growth include: mineral salts of variable concns; various hydrated substances, especially of carbon, in presence of good nitrogen source; organic acids, especially acetic acid, but also lactic acid, malic acid, and to certain extent, butyric acid; and organic nitrogen compds. That single biological proofs of poln. should assume same value given to single chem. analys., and that a poln. demonstrated only biol. verification, made with care and precision, should be recognized judicially in absence of chem. anal., or in presence of a contradictory chem. anal. is concluding hope provided by author. —*PHEA*

(Continued on page 80 P&R)

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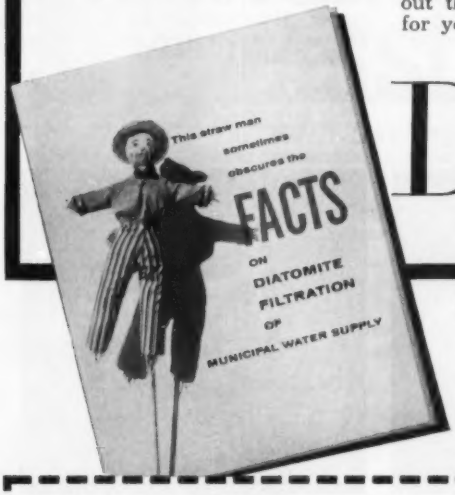

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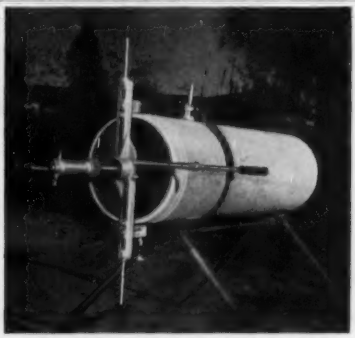
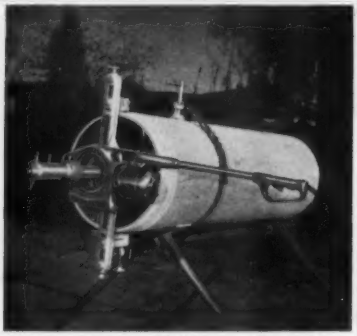
(Continued from page 78 P&R)

Factors Affecting the Pollution and Self-Purification of Molluscan Shellfish. P. C. Wood. J. Conseil, Conseil Permanent Intern. Exploration Mer. (Den.), 22:200 ('57). Study was made of processes of poln. and self-purification in oysters and muscles in an estuary subject to intermittent sewage poln. It was found that, when water temp. is above 10°C, both poln. and cleansing takes place rapidly as qual. of water overlying bed alters, and at these temps. both types of shellfish may become highly pold. When temp. of water is about 1°–2°C, mussels continue to show same pattern of poln. and cleansing, but oysters may not become pold., even when water overlying them contains large nos. of fecal bacteria. When water is turbulent, cycle of poln. and cleansing is not in evidence, and this is attributed to interference of normal functioning processes by excessive turbidity. It is suggested that it might be possible when water temps. are low enough, to make it possible to market oysters from pold. waters. —*WPA*

TREATMENT—GENERAL

Oxygen Absorption Rates in Sodium Sulfite Solutions. Comparison of Copper and Cobalt as Catalysts. S. J. Pirt; D. S. Callow; & W. A. Gillett. Chem. Ind. (Br.), 730 ('57). Aeration efficiency of an apparatus is frequently detd. by measuring rate of absorption of oxygen by a soln. of sodium sulfite in apparatus. Both copper and cobalt have been used as catalyst by various workers, and authors have now carried out expts. to compare rates of oxygen absorption obtained with two catalysts. Oxygen absorption rates were detd. in 2 ways, by titration of sulfite and by analysis of gas flowing out of apparatus, and good agreement was obtained between these methods. It was found that use of cobalt as catalyst increased rate of oxygen absorption by amts. varying, with rate of air flow, from 2 to 5 times the rate of absorption in presence of copper. It is concluded that copper is preferable as a catalyst when comparing aeration systems.—*WPA*

(Continued on page 82 P&R)

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(Continued from page 80 P&R)

Cerimetry Applied to Analysis of Water. H. LECOQ. Chim. anal. (Paris), **39**:232 ('57). O uptake of raw H_2O is best detd. by using $Ce(SO_4)_2$. Reflux 100 ml raw H_2O, 3 ml concd. H_2SO_4, and 25 ml of 0.125 or 0.0125*N* $Ce(SO_4)_2$ soln. in 3% H_2SO_4 for 20 min, cool, and back titrate with $FeSO_4$ soln. to a ferroin endpoint.—*CA*

The Effect on Fish of Toxic Substances in Waste Waters. W. BUCKSTEEG; H. THIELE; & K. STÖLTZEL. Vom Wasser (Ger.), **22**:194 ('55). Expts. are described on effects of phenol, *o*-, *m*-, and *p*-cresol, *o*-, *m*-, and *p*-xylenol, pyrocatechol, pyrogallol, and hydroquinone on perch, minnows, and eels. Apparatus used is described and illustrated and results are given in tables and curves. Highest toxicity was found with *p*-xylenol, of which toxic limit for perch was about 2 mg/l. Effect of combinations of different phenols was additive. Effect of presence of other poisons (for example, cyanide) in waste waters must be taken into account. Slow increase in the concn. of phenol leads to a considerable increase in resistance. Sudden variations in temp. shorten manifestation times, but slow alterations, such as seasonal variations, have little or no effect.—*WPA*

Environment and Time in Fish Toxicity. J. CAIRNS. Ind. Wastes, **2**:1 ('57). Author discusses toxicity of industrial waste waters to fish. Expts. have shown that idea that fish avoid toxic materials in water is a false one. Factors to be taken into consideration when planning bioassay tests include variations in natural conditions which affect toxicity of certain compds. Variations in temp., hardness, pH, and DO content were all found to affect toxicity of such substances as potassium dichromate or naphthenic acid. Synergism and antagonism of waste substances in water must also be studied. Expts. showed that whereas minnows could stand a concn. of 8.0 ppm zinc or 0.2 ppm copper alone for 8 hrs, if both were mixed together minnows succumbed in a soln. contg. only 1.0 ppm zinc and 0.025 ppm copper. Alternatively antagonism of substances may produce a biol. safe waste water. Other factors to be considered are variability of natural pop. and time taken to make accurate bioassay tests. Therefore, each test should take all variable factors into account.—*WPA*

Fish Toxicity Tests and Water Quality. E. LECLERC & F. DEVLAMINCK. Bul. Centre Belge Document. Eaux (Belg.), **28**:111 ('55). Authors discuss limitations of toxicity tests using fish to assess qual. of a water. It is pointed out that studies on toxicity of water to fish do not provide information on the bact. purity of water; its fitness for use by animals and humans; absence of tastes and odors; absence of substances toxic to man, domestic animals, or plants; hardness and salinity of water for industrial use; color, turbidity, or suspended matter it contains. In addition, fact that water is potable does not mean that it can support fish life; for example, fish would die in chlorinated water. It is concluded that fish toxicity tests are of use only for detg. effect of a given effluent on fish in a river and dilution or degree of treatment required to prevent fish mortality. Tables are given showing min. lethal dose of certain toxic substances, and compn. and characteristics of a good-quality water.—*WPA*

Toxicity Studies on One-, Thirty-, Sixty-day-Old and Adult *Stagnicola reflexa*. R. A. WOOD. Proc. Ind. Acad. Sci. (India), **64**: 291 ('55). Effects of copper and magnesium sulfates and carbonates and sodium chloride on snail *Stagnicola reflexa* were compared. Snails of different ages were exposed to varied concns. of salts for different periods of time. Copper carbonate and copper sulfate were most toxic, latter particularly so in case of adult snail.—*WPA*

CHEMICAL ANALYSIS

On the Vertical Distribution of the Dissolved Oxygen in the Ocean. Y. MIYAKE & K. SARUHASHI. Deep Sea Res., **3**:242 ('56). Assuming that about 90% of oxygen consumption in sea water is due to oxidation of organic carbon to carbon dioxide, amt. of carbon dioxide calcd. from oxygen consumption was subtracted from tot. concn. of carbon dioxide present at 2 sampling stations in northeast Pacific. When remainder was divided by chlorinity, a nearly constant value was found from surface to a depth of 2000 m, thus verifying validity of assumption. Seasonal variations in integrated oxygen consumption in water column to a depth of 1,000 m were then compared with similar variations in vols. of plankton taken from upper 100 m at 2 stations in western Pacific. These

(Continued on page 84 P&R)

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(*Continued from page 82 P&R*)

values were found to vary similarly throughout year. These results, and observations of other authors that oxygen min. occurs at nearly same density through much ocean, lead to conclusion that local productivity and vertical distribution of density are important factors in detg. vertical distribution of DO and in accounting for occurrence of min. oxygen concns. at intermediate depth in ocean.—*WPA*

Notes on Oxygen Sampling on the Fladen Ground. J. H. Steele. J. Marine Biol. Assoc. United Kingdom (Br.), **36**:227 ('57). During study of oxygen and phosphate data from Fladen Ground, in North Sea, it was found that usually accepted oxygen-phosphate ratio (1μg atom phosphorus equals 2.36 ml oxygen) did not agree with changes below euphotic zone. An alternative factor was calculated, and was found to be 1μg atom phosphorus equals 3.87 ml oxygen. Problems concerning surface exchange and production are discussed briefly.—*WPA*

The Physicochemical Investigation of Hot Spring Waters of Tbilisi. D. I. Eristavi & N. A. Kituashvili. Trudy Gruzin. Politekh. Inst. (USSR), 5:56 ('55). 6 wells and 2 springs of thermal (up to 45°) waters of Tbilisi which were investigated are divided into 2 groups: (1) neutral (or weakly alk.) waters of the drilled well No. 6 and of the spring Gogilo (the mineral content is 741.4; 1096.9 mg/l, and the temp. is 26.8°; 28.0°, resp.); (2) alk, with a low mineral content (306.1–442.4 mg/l). The Tbilisi mineral waters are supposed to be of mixed origin. The content is (in g/l): Cl 0.0532–0.2769; SO_4^{--} 0.0419–0.3081; HCO_3^- 0.0338–0.1191; $Na^+ + K^+$ 0.0740–0.1545; Mg^{++} 0.0026–0.0445; Ca^{++} 0.0060–0.1700. The elec. cond. increases with the increase of the tot. mineral content. The pH (with a glass electrode) and the oxidation-reduction potential were detd. The first group of Tbilisi thermal waters had reducing properties; the pH is 7.31–7.45. The second group has oxidizing properties; the pH is 8.22–8.95.—*CA*

(*Continued on page 86 P&R*)

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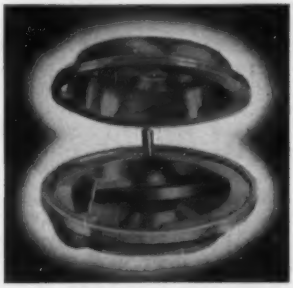

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(*Continued from page 84 P&R*)

The Mineral Springs of Esaulovo and Gonzha. A. P. Georgievskii. Voprosy Geograf. Dal'n. Vostoka (USSR), **2**:140 ('55). Water of mineral spring Esaulovo, in valley of Undurchukan R., contains $NaHCO_3$, with temp. 4°, is clear, and has an odor of H_2S. The water is similar to the water of the thermal springs of the health resort Kul'dur. Analysis is K 0.0039, Na 0.1392, Ca 0.0074, Mg 0.0028, Fe^{++} 0.0001, Cl 0.0106, SO_4 0.0123, HCO_3 0.3783, dry residue 0.3810, free CO_2 0.0132, H_2S 0.0005, H_2SiO_3 0.0098 g/l; the oxidizability is 0.0026. The spring is not capped. The mineral spring of Gonzha (along the Amur railroad), with a primitive capping (which does not exclude the infiltration of ground water), surpasses by its free CO_2 content the spring of Zheleznovodsk and the Narzan springs of Kislovodsk. Its water is carbonate, HCO_3–Ca–Mg. Analysis is K 0.01639, Na 0.01750, Ca 0.45846, Mg 0.11921, Fe^{++} 0.00810, Fe^{+++} 0.00630, Cl 0.04255, SO_4 0.00831, HCO_3 2.02586, free CO_2 2.17800, H_2SiO_3 0.06900 g/l; the oxidizability 0.01535; dry residue 1.67430 g/l. The water of the mineral spring Gonzha has high salutary properties.—*CA*

LABORATORY AND FIELD METHODS

Determining Potability of Water Supplies in the Field. Harold J. Fournelle. US Armed Forces Med. J., **8**:713 ('57). Simple and effective procedure for detg. potability of water supplies in field is described. Inoculation of media in field is feasible procedure. It is applicable to bact. examn. of turbid waters such as often found in samples from surface supplies in rural Alaska. This procedure is believed to be especially adapted to those areas where an inordinate amt. of time is required for samples to reach lab. after collection. Furthermore, method gave considerably fewer false negative results than std. test when performed on shipped, unrefrigerated water samples.—*PHEA*

An Automatic Molluscicide Dispenser for Use in Flowing Water. J. W. Klock. Bul. World Health Organization, **14**:4:639 ('56). Author describes design and operation of automatic molluscicide dispenser for use in flowing water. Equip. which consists basically of measuring weir coupled to float-activated siphon, was designed for simplicity, low cost, constr. with commonly available materials, and operation by untrained personnel. Observations in field have shown that dispenser increases accuracy and consistency of dosage, reduces manpower requirements, and improves molluscicidal effectiveness.—*PHEA*

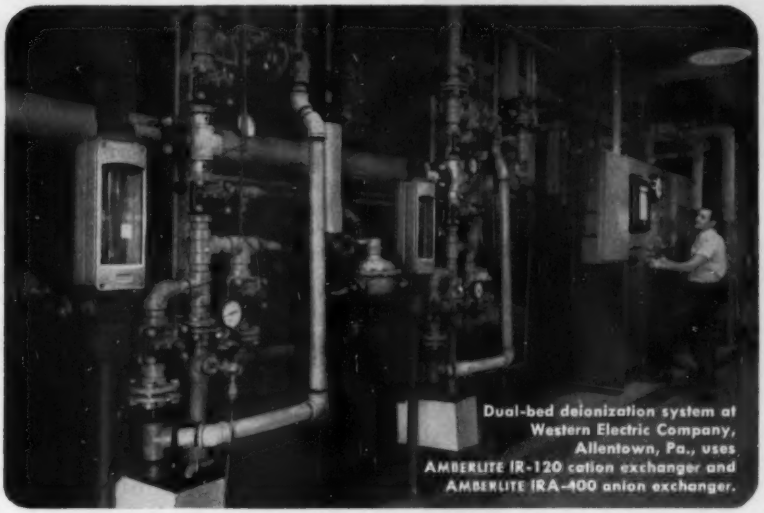
Fluorescent x-Ray Spectrographic Determination of Uranium in Waters and Brines. W. L. Kehl & R. G. Russell. Anal. Chem., **28**:1350 ('56). U is pptd. from water or brine by method of Smith and Grimaldi and ashed ppt. is analyzed by fluorescent x-ray spectrography in a special x-ray spectrograph in which sample holder is modified so as to place small pptd. samples in most intense part of beam from the Mo target x-ray tube. Internal std. of Y is employed. As little as 0.01 mg of U, equiv. to 0.01 ppm in 1-liter water sample, can readily be measured when matrix contains no appreciable concn. of highly absorbing elements.—*CA*

Determination of Selenium. D. N. Fogg & N. T. Wilkinson. Analyst (Br.), **81**:525 ('56). Detn. of Se in waters is unsatisfactory because sample and std. are not the same. Isolation of Se via HBr-Br_2 distn. as std. yields turbidities which are comparable. To destroy org. matter $HClO_4$ should be added to HNO_3-H_2SO_4 mixt.—*CA*

Rapid Method for the Determination of Calcium in the Presence of Magnesium. G. B. Pasovskaya. Trav. Comm. Analyt. Chem., Acad. Sci. USSR, **7**:272 ('56). Analyt. Abstr., 1957, **4**, Abstr. No. 2905. To det. calcium in presence of magnesium, sample is placed in conductimetric titration apparatus, and 1 ml of saturated alcoholic solution of magneson II and 0.5 ml aqueous ammonia are added. Mixture is diluted to 20 ml and titrated with normal potassium oxalate soln. which has previously been standardized against calcium chloride soln. If ratio of magnesium to calcium is 7:1 addition of std. calcium chloride, and dilution of whole soln. to give calcium chloride concn. of 0.01–0.02*N*, is recommended. Maximum error obtained is not greater than 0.97%. Presence of sodium and potassium does not interfere with detn.—*WPA*

(*Continued on page 88 P&R*)

ION EXCHANGE RESINS aid transistor production



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(*Continued from page 86 P&R*)

Evaluation of BOD Bottle-Cleaning Techniques. JOSEPH P. MASCARENHAS & GERHARD KLEIN. Sew. & Ind. Wastes, **30**:976 ('58). Several methods of cleaning BOD bottles were compared in order to find methods equiv. to reference procedure (chronic acid treatment), but more convenient. It was established that detergent ("7X") gave results quite comparable in reproducibility to reference method. Other treatments gave less reproducible results but in general fell within limits given by *Standard Methods*. Reference method itself gave rise to more reproducible results than stipulated in *Standard Methods* and was thus confirmed as most suitable std. method, although some of alternate methods tested were demonstrated to be sufficiently precise for most work.—*PHEA*

Mass Spectrometric Determination of Volatile Solvents in Industrial Waste Water. G. P. HAPP; D. W. STEWART; & H. C. COOPER. Anal. Chem., **29**:68 ('57). Variety of volatile organic compds. dissolved in water can be identified and their concns. detd. with mass spectrometer. There is no interference by dissolved or suspended solids, as only vapor above soln. in absence of air, is admitted to instrument. Batch samples of few ml can be used in static method, or continuous monitoring techniques can be applied to waste streams.—*WPA*

Spectral Analysis of Natural Waters in Air-Acetylene Flames. Z. V. GUSYATSKAYA. Sbornik Nauch.-Tekh. Inform. Ministerstva Geol. i Okhrany Nedr. (USSR), No. 1: 138; Referat. Zhur., Khim, Abstr. No. 58479 ('56). Direct evapn. of residues of natural waters in air-C_2H_2 flames permits detn. of 0.003% Rb and Cs and 0.0005% Li in residues of homogenous compn. with probable error of ±15–20%. In detn. of Rb, Cs, and Li in pegmatites, it is advisable to pretreat materials chemically in order to remove alk. metals. In detn. of Rb, Cs, and Li in soln. from intensities of their lines, accuracy of detn. of 0.001–0.03% Rb and Cs is ±4–5%; in the detn. of $3 \times 10^{-6} - 1 \times 10^{-3}$% Li probable error is ±7%. Interaction of alk. metals was established, and method for their removal is proposed.—*CA*

(*Continued on page 90 P&R*)

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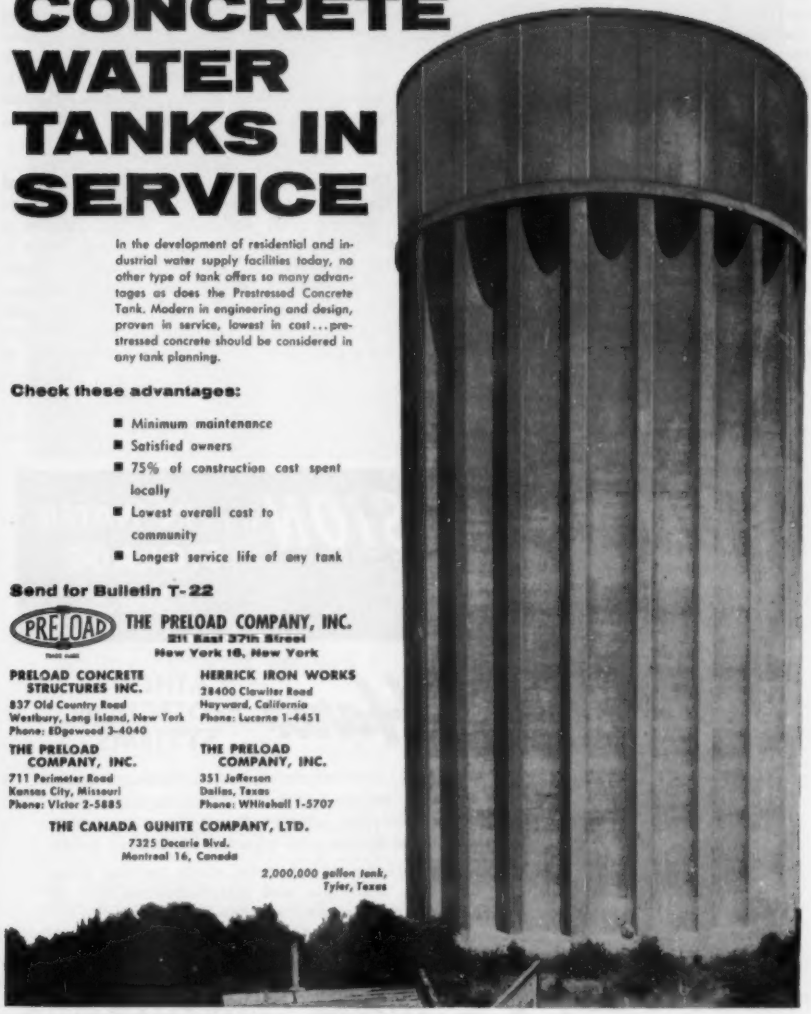

2,000,000 gallon tank, Tyler, Texas

(*Continued from page 88 P&R*)

Use of the Kjeldahl Micromethod in the Determination of Organic Nitrogen in Underground Waters. M. YA. DUDOVA. Trudy Vsesoyuz. Nauch.-Issledovatel. Inst. Gidrogeol. i Inzhener. Geol., Sbornik (Russ.), No. 15: 145 ('57). As content of ammonium salts (**I**) is much higher than content of org. N in series of underground waters, it is necessary to eliminate **I**, without removing org. N. Method selected consisted of preliminary distn. of NH_3 with phosphate buffer at pH 7.4 (*Standard Methods*) phosphate buffer, however, being changed to a borate buffer, owing to interference of large amts. of Ca and Mg phosphates when these 2 metals are present in great quantities. Results are reproducible within ±2% with an avg. error of 2.5%. H_2S (up to 5 mg) and Cl^- (up to 500 mg) do not affect the results. NO_3^- and NO_2^- interfere yielding low results, decrease being proportional to the ratio nitrate-nitrite N:org. N. For example, if content of nitrate N is 6 times greater than content of org. N, complete loss of org. N occurs. On other hand, 10-fold excess of org. N causes error of only 4%. Absorption of NH_3 is best carried out in K biiodate, with subsequent iodometric detn.—*CA*

New, Simple Field Test for Nitrates. R. S. ROBERTSON & B. J. WACHTER. Power, 102:7:105 ('58). Advantage of knowing importance and dangers of nitrates, and amount present in a water supply, is stated. Method is described, using stable reagents, available for field work. Complete test can be made in less than 10 min. Making of reagents is described and illustrated.—*CA*

Determination of Microquantities of Copper, Lead, and Zinc in Natural Waters and Soil Extracts. A. D. MILLER & R. I. LIBINA. Zhur. Anal. Khim. (Russ.), 13:664 ('58). 2 procedures are outlined. In one, Cu, Pb, and Zn are extd. as dithizonates in CCl_4 from weakly ammoniacal soln. in presence of NH_4 citrate. Pb and Zn are reextd. in 0.01–0.02*N* HCl. Cu is detd. in

(*Continued on page 92 P&R*)

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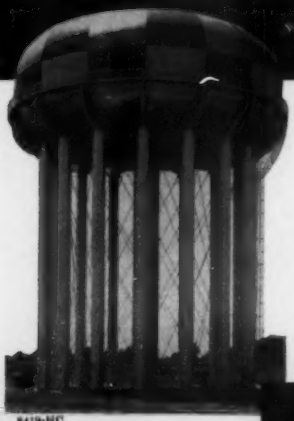

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(*Continued from page 90 P&R*)

org. ext. The aq. layer is made alk. and Zn and Pb are again extd. with dithizone in CCl_4. Addn. of $Na_2S_2O_3$ returns Pb into aq. layer in which it is detd. as dithizone. Zn remaining in aq. layer is similarly detd. The 2nd procedure is based on difference in soly. of Cu, Zn, and Pb diethyldithiocarbaminates in HCl of varying concn. Neither of procedures requires KCN and both are suitable for use in field.—*CA*

Sulfide Colorimetric Determination. W. H. OLDAKER. Sanitalk, **4**:14 ('56). Modification of methylene blue test for detn. of sulfide was developed for use in controlling daily chlorine dosage applied to flax wastes from manufacture of cigarette papers. Modification involves use of spectrophotometric method which eliminates use of comparator tubes and methylene blue standard solns. Max. absorbance takes place at 668 mμ in series of flax wastes investigated.—*WPA*

Use of a Simplified Alizarin-Zirconium Method for the Estimation of Fluoride in Ground Waters of Koszalin District. KRZYSZTOF KORZIEWSKI. Roczniki Panstwowego Zakladu Hig., **9**:283 ('58). Methods of fluoride detn. in water are described. Simplified alizarin-zirconium ($ZrOCl_3$) method was used to est. F in water. Optimal values of F, 0.8–1.0 mg/l, were not found.—*CA*

Determination of Chlorides in Water According to the Mercury(II) Thiocyanate Method. H. AMBUHL. Mitt. Gebiete Lebensm. u. Hyg. (Ger.), **49**:241 ('58). Modification of method has been described. Prepn. of modified $Fe(ClO_4)_3$-$HClO_4$ reagent and mercury (II) thiocyanate soln. are given in detail. Max. absorption of color is at 490 mμ. Beer's law does not apply. Method is good for 0–20 mg Cl^-/l and precision is 0.05–0.2 mg/l. NH_4^+, SO_4^{--}, PO_4^{---}, and NO_3^- do not interfere. NO_2^-, Hg^{++}, and Fe^{+++} interfere. High concns. of EtOH, iso-PrOH, tartaric acid, and acetone influence color development.—*CA*

A New Large-Surface Flow Counter as a Means for Improved Determination of the Gross Radioactivity in Water by the Evaporation Method. H. KIEFER & RUPPRECHT MAUSHART. Nukleonik (Ger.), **1**: 103 ('58). Windowless flow counter with 7 counter wire loops and with useful surface of 300 sq cm is described. Water in large Al dishes, placed in bottom of the casing of flow counter, can be evapd. directly with surface evaporator. Improvement obtained in this manner over some common methods of evapn. is shown with aid of comparison measurements.—*CA*

Determination of the Biochemical Oxygen Demand (BOD) of Toxic Effluent Waters With a Warburg Apparatus. E. LEIBNITZ; U. BEHRENS; & W. WINTER. Wasserwirtsch.-Wassertech. (Ger.), **8**:410 ('58). Effluent waters contg. phenols are oxidized by bacteria in a Warburg app. and the O uptake is measured at 24, 48, and 96 hr. In order to measure large O uptake, manometers are periodically vented and restandardized. Periodic values obtained are then added together to get the tot. O uptake for overall reaction time.—*CA*

Partition Chromatographic Separation and Determination of Monophenols in Effluent Waters. E. LEIBNITZ; U. BEHRENS; & A. GABERT. Wasserwirtsch.-Wassertech. (Ger.), **8**:170 ('58). Samples of effluent water are chromatographed on columns of silica gel, by using H_2O as stationary phase, and eluting with cyclohexane. Fractions of 4–5 ml are collected. Treatment of fractions with *p*-aminodimethylaniline and $K_3[Fe(CN)_6]$ at pH 8.3–8.7 gave indophenol derivatives which were extended into cyclohexane. Color was measured in colorimeter.—*CA*

RADIOACTIVITY

Problems of Nuclear Physics and Nuclear Chemistry in the Realm of Water Supply. W. CHRIST. Wasserwirtsch. Wassertech., **6**:211 ('56). After a survey of fundamental points in nuclear physics, including types of radiation and units and methods of measurement, possibilities of use of radioactive isotopes in connection with water supply are discussed. Among uses are measurement of height of snow for forecasting high water flows, investigation of flow in ground water, lakes, reservoirs, rivers, and sewage treatment plants, investigation of processes in biol. treatment plants, and detection of leaks in pipes. Expts. have been started on tracing movements of bacteria cultured on radioactive nutrient media. Gamma-radiation has been used experimentally in USA for disinfection of waste waters; costs would be less than for chlorination. Protection of

(*Continued on page 94 P&R*)

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(*Continued from page 92 P&R*)

water supplies from radioactive poln. and effects of such poln. on humans, half-life and tolerance values of various isotopes, and origin and properties of radioactive waste waters are discussed. Radioactive waste waters can be treated by storage, dilution, or removal of active material by distillation, chemical precipitation, filtration, ion exchange, or biol. treatment. Final concentrate must be destroyed by burning, buried, or sunk in sea. Expts. have shown that clay strata are best suited for disposal. Risks of accumulation of radioactive material in animals and plants are considered.—*WPA*

Bioaccumulation of Radioisotopes Through Aquatic Food Chains. J. J. Davis & R. F. Foster. Ecology, **39**:530 ('57). Some radioactive materials introduced into aquatic environments may be accumulated by organisms. Amt. of accumulation will vary over many orders of magnitude depending on kinds of isotopes and many phys., chem., and biol. factors. Such concn. is of considerable importance in control of radiological hazards and aquatic biologist has definite responsibilities in this area. Process of adsorption and absorption are of major importance in uptake of radioisotopes by plants but appear to be of less importance than food chain in uptake by aquatic animals. Concn. of radioactive substances will vary between species and tissues and will fluctuate according to food habits, life cycles, and seasonal changes. Within biotic mass, a major fraction of most radioactive contaminants will be held by organisms which make up the primary trophic levels. In a flowing stream, specific activity of a radioisotope will diminish along food chain. When turnover rates of certain isotopes can be measured, inferences can be drawn on feeding habits.—*PHEA*

Quantitative Determination of Strontium-89 and Strontium-90 in Water. J. Kool. Anal. Chem., **30**:532 ('58). A simple procedure has been developed for quant. detn. of radioactive strontium in water which may be rich in calcium. Strontium-89 and tot.

(*Continued on page 96 P&R*)

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(*Continued from page 94 P&R*)

radiostrontium may be obtained in about 5 hr, and strontium-90 may be estd. by allowing ppt. to stand overnight and separating yttrium-90. Sensitivity is better than 0.1 of the internationally recommended MPC. Method is specific for strontium and suitable for large-scale, routine application. Radioactive barium may also be detd.—*PHEA*

Natural Radioactivity in Water. H. KIEFER & R. MAUSHART. Nukleonik (Ger.), 1:22 ('58). Proportions of separate components of natural radioactivity in most diverse waters were investigated. To this end, several methods of measurement were satisfactory; however, chem. pptn. procedures were mostly employed. Particularly, conclusions were made concerning change of Rn content of surface waters with water depth and with subsoil, deviations from equil. state between Rn and its decay products in water flowing through piping and filters, and ratio of natural to artificial activity in water.—*CA*

Field Test of the Movement of Radioactive Cations. B. B. EWING. Proc. ASCE, **85**:SA1, Paper 1929, p. 39 ('58). Sr^{89} dild. to 0.94×10^{-5} mc/ml, and Cs^{134} dild. to 3.8×10^{-5} mc/ml were injected into an aquifer of unconsolidated pea gravel and sand strata averaging 4.4 ft thick. After 94 days of injection at a rate of 35.5 gpm, no Cs was detected at 2 wells each about 13 ft away, but Sr breakthrough increased to over 90% of feed activity in less than 40 days. Redevelopment of well by pumping produced some Cs^{134} activity which was essentially all held on clay particles by ion exchange. No Sr^{89} was removed by short pumping required for redevelopment.—*CA*

Decontaminating Radioactive Water. W. J. LACY & W. DE LAGUNA. Ind. Eng. Chem., **50**:1193 ('58). Polymer coagulants used to coagulate and ppt. large dosages of several types of ferruginous, calcareous, and glauconite shales were slurried in contamd. tap water to remove radioactive nuclides by adsorption and base exchange. Dosages of high mol wt polyelectrolyte required for coagulation were found to be very small. Various types of shale remove radioactive contaminants from water, but effectiveness depends on the chem. properties of nuclides and shale. Radioactive nuclides used as contaminants were: Sr^{90}–Y^{90}, Ce^{137}–Ba^{137}, Ru^{106}–Rh^{106}, Ce^{144}–Pr^{144}, and a fission product mixture, MFP. When using these polyelectrolytes as coagulants max. possible removal of radioactive material was obtained by slurrying shale for 30 min followed by adding coagulant, 5 min of rapid mixing, and 15 min of settling.—*PHEA*

Ion Exchange; Five Contributions to Nuclear Technology. L. D. ROLAND. Atomics, **8**:131 ('57). Author outlines the uses of ion exchange in atomic energy field, which include extraction and purification of uranium, zirconium purification, treatment of water for nuclear reactors, and radioactive waste treatment. Ion exchange is used for softening and demineralization of water for use in cooling circuits and for boiler feedwater in nuclear reactors. Low- and high-activity waste waters from various nuclear activities are treated by ion exchange to conc. activity. Resin from such plants is not regenerated, but disposed of as a solid contaminated material, or incinerated, thus further concg. activity.—*WPA*

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(Continued from page 50 P&R)

Two new AWWA docs were created last June when Rutgers University conferred an honorary doctor of science degree upon Edward J. Cleary, executive director and chief engineer, Ohio River Valley Water Sanitation Commission, and Pennsylvania Military College gave an honorary doctor of laws degree to Francis S. Friel, president, Albright & Friel, Philadelphia consultants. Ed Cleary was cited as:

Native son of New Jersey, sanitary engineer, distinguished Rutgers alumnus. As reporter and editor, you have recorded engineering achievements throughout the Western Hemisphere; as consultant and director, you have forged closer ties within the engineering profession in the Americas. Under your administration the Ohio River Valley Water Sanitation Commission has become the model compact wherein industry and government can work together to restore the regional heritage of a great river.

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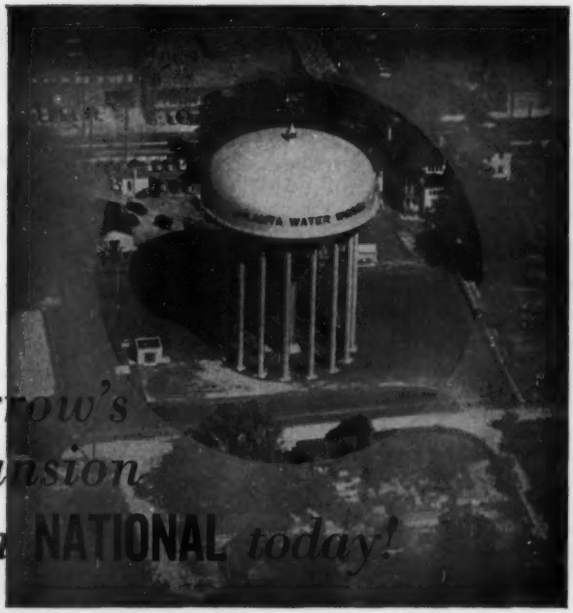
Francis S. Friel receives the academic hood, symbolic of a doctorate degree, from Pennsylvania Military College administrative officers Chester H. Sloat (left) and Lt. Guilio DiSerafino (right). See story above.

(Continued on page 100 P&R)



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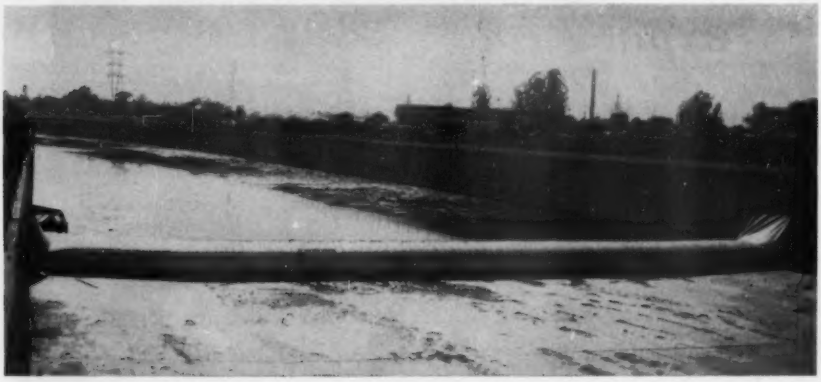
(Continued from page 98 P&R)

number, of civil engineering projects which he has directed is remarkable, and indicative of varied interests and vast technical knowledge. He has had responsible association with over 2,065 different civil engineering projects, involving a construction cost exceeding $1,250,000,000. He has found time with all this to publish more than 60 articles on engineering works, including a book on standard specifications. . . .

To Dr. Cleary and Dr. Friel our congratulations. And to Rutgers and PMC our congratulations, too, for recognizing merit and recognizing it!



Dammed cleverly is the Los Angeles River channel these days by a rubber barrier that diverts water to the Los Angeles water department's spreading grounds during normal flows but collapses when waters reach a predetermined height, to help prevent flooding. Designed by AWWA member Norman Imbertson, engineer in charge of water operations for the Dept. of Water & Power, the collapsible barrier was the solution to the problem of preventing the loss of 3,000 acre-ft of water per year which ran off into the Pacific when the wooden dam formerly used had to be removed each winter to comply with Army Engineer Corps flood control regulations. With materials and fabrication problems worked out in consultation with Firestone Tire & Rubber Co., the dam was constructed as a flexible tube (150 ft long and 8 ft in diameter) that can be filled with water to block the stream (see cut) and siphoned empty to permit free flow. Filling requires 25 min and emptying only 10.

With its practicality proved in a demonstration before Army engineers in June and with the promise of $75,000 worth of additional water per year from the $10,000 investment involved, the department is now planning a second installation at another location on the river. Meanwhile, inventor Imbertson, who has applied for a patent, looks forward to possible customers among irrigators who want to divert water without permanently blocking a stream.

Damned clever these Los Angelese!

George E. Symons, formerly editor of *Water & Sewage Works,* has re-

(Continued on page 102 P&R)

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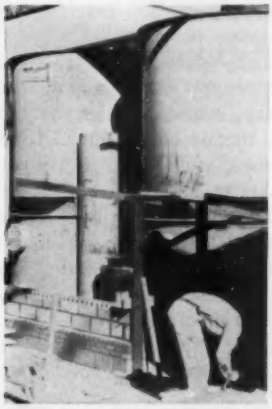
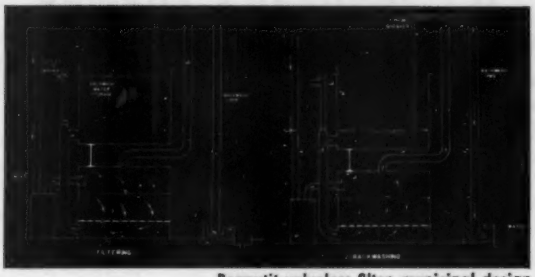


Automatic valveless filters, like this tandem setup photographed during its installation at an Eastern municipality, are now in service.



Permutit valveless filter, municipal design

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The only filter that works by itself

We sell most of our Permutit valveless filters simply by pointing out the things you *don't* have to do and the things you *don't* need once you install one:

Manpower — None needed. No valves to operate, gauges to watch, pumps to start or stop, or decisions to be made.

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Flow controller — No mechanical, pneumatic, or hydraulic devices needed . . . unit filters whatever volume you deliver.

Maintenance — None, outside of normal, routine painting. No moving parts to wear out.

The best part of our story is the fact that this filter costs less than conventional gravity filters, either manual or automatic.

The basic laws of hydraulics behind this filter's design show in the diagrams. If you're rusty on your hydraulics, or are just plain interested, we invite you to write for our bulletin on valveless filters.

Address yourself to our Permutit Division, Department JA-89, 50 West 44th Street, New York 36, New York.

PFAUDLER PERMUTIT, INC.

Specialists in FLUIDICS . . . the science of fluid processes

(*Continued from page 100 P&R*)

turned to consulting work on a full-time basis in the fields of sanitary engineering and technical editing and writing. He will maintain his office in Larchmont, N.Y.

The teeth of the California Water Plan were finally provided when the state legislature in mid-June approved a $2 billion program to develop the largest water system in the world, as the thirsty South and the waterful North compromised for the benefit of the state as a whole. It remains now to provide the roots for those teeth—the grass roots—as the program requires ratification by the voters in the November 1960 election, with approval of an approximately $1,750,000,000 bond issue. That will take a selling job, of course, but selling water to Californians is selling them something they want and appreciate and have always been willing to pay for. The bite will be a big one, but tasty and nourishing for all concerned.

The Special Research Meeting of the National Technical Task Committee on Industrial Wastes, held at the USPHS Robert A. Taft Sanitary Engineering Center in Cincinnati, Apr. 27–28, closed on a note of optimism concerning progress in water pollution. The members of the committee, however, restated their awareness of the need for close cooperation between government and industry in dealing with the problems of water supply and pollution now facing the nation. The 60 scientists and business executives in attendance met to review current industrial-waste treatment research and to be briefed on the aim, scope, and direction of water research at the Sanitary Engineering Center.

Based on the reports received during the special meeting, the committee concluded that improved communication on water pollution between government and industry was an important requirement for future progress, a point made during the opening session by both Harry G. Hanson, director of the Sanitary Engineering Center, and Bernard B. Berger, chief of water supply and water pollution research at the center. Harry A. Faber, research grants coordinator for the USPHS Engineering Resources Program, told the group that research grants in the water field awarded during the present fiscal year now total approximately $1,350,000 and support 117 projects.

The Sanitary Engineering Center reports on research dealt with the following:

1. Waste characterization—studies on the treatability and persistence of specific organic compounds, fish bioassay studies, and characterization of wastes from catalytic cracking of petroleum.

2. Industrial-waste treatment—Sanitary Engineering Center consultation with industry, studies on the effect of toxic heavy metals on biological treatment processes, studies on the conversion of sugars in spent sulfite liquor to fumaric acid, studies on the selection and adaptation of microorganisms to degrade specific wastes, and development of an industrial-waste guide for uranium ore refineries.

3. Stream studies—studies on organic contaminants, microbial contaminants, dissolved-oxygen requirement of fish and other cooperative studies at the Corvallis, Ore., field station, and effect of impoundment on dissolved oxygen.

4. Sewage treatment—waste stabilization ponds, studies on bio-oxidation

(*Continued on page 104 P&R*)

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Its bore stays clean year after year for uninterrupted, trouble-free service

"K&M" Asbestos-Cement Pressure Pipe is as modern as the Jet Age in which we live.

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(Continued from page 102 P&R)

surfaces, treatment of sewage by anaerobic contact, and studies on soil absorption of liquid effluents.

5. Water treatment—municipal water treatment studies and studies on nuisance organisms.

Engineering-Science, Inc., consulting and research firm of Pasadena, Calif., has opened a new office and laboratory at 4144 Telegraph Ave., Oakland, Calif.

John W. Lawrence has accepted the position of manager of Alton (Ill.) Water Co., succeeding Frank H. King, who has retired. Lawrence was formerly assistant manager of East St. Louis & Interurban Water Co. in Missouri.

Salt water injection on a large scale is being undertaken by major oil producers in the Long Beach, Calif., vicinity to counteract ground subsidence at the Wilmington Oil Field there (see the article by Shoemaker and Thorley in the April 1955 issue, p. 412). Ultimately it is planned to inject at high pressure about 35 mgd of water supplied by a system comprising source wells, pumping installations, pipelines, and treatment facilities to prevent corrosion and bacterial fouling. The initial phase of the program, limited to two fault areas in the oil field, is to be completed this autumn. Consulting engineer on the project is M. A. Nishkian & Co., of Long Beach. Pumps and motors will be installed by Byron Jackson Pump Co.

John W. Hodgson Sr., director of the Jefferson Parish Water Dept., New Orleans, La., died May 26, 1959. He was 58. He had been president and general manager of the East Jefferson Water Works Dist. No. 1 for 29 years, until last October, when all districts of the parish were merged. Mr. Hodgson had been an AWWA member since 1942.

George G. Papesch, assistant superintendent, Erie (Pa.) Bureau of Water, died at the age of 67. He had been a Water Bureau employee for 51 years, starting as a waterboy and laborer and later serving as filter operator and chemist. At the time of his death he was head of the filter plant and was in charge of treatment. He had been a member of AWWA since 1946.

Employment Information

Classified ads will be accepted only for "Positions Available" or "Position Wanted." Rate: $1.50 per line (minimum $5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Positions Available

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Man with formal education and diversified experience in Public Health Engineering to assume full responsibility for all phases of watershed control work, including administration of department and supervision of personnel. Forward complete resume to: Personnel Director, HACKENSACK WATER COMPANY, 4100 Park Ave., Weehawken, N.J.

Positions Wanted

Engineer from Australia, experienced particularly in water purification plant design, wants temporary one-year job as engineer-draftsman. References available. George Kaldor, Flat 15, 126 Alma Rd., St. Kilda, Victoria, Australia.

Man experienced 8 years as supervisor of industrial and domestic water treatment system desires work in water works field. Box 981W, Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

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Griffin-20 Trademark

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Pipe Available March, 1960

Conversion of the existing Griffin foundry, and the installation of pipe-producing equipment are scheduled for completion in a few months. Joints to be offered include slip-on, mechanical, and bell and plain end. All pipe will be cement-lined to full specification thickness, half thickness, or uncoated, as required.

10% Fewer Joints

Market surveys conducted among water works operators, city engineers, consultants, and piping contractors in the Plains States overwhelmingly pointed to the need for longer lengths to help reduce mounting labor costs in installing pipe. Griffin-20 pipe decreases the number of joints by 10 percent, as compared to conventional 18-foot lengths.

Many Foundry 'Firsts'

In its 82-year history, Griffin research has made many contributions to ferrous metallurgy, including the de-sulphurization of molten metal with the use of briquetted soda ash known as Purite; the hot blast cupola; use of tellurium for improved chill control in the manufacture of chilled iron castings; mechanical molding of chilled car wheels, and many others. More recently, Griffin perfected a process for the pressure pouring of molten ferrous metals in permanent graphite molds. Griffin's new research center, now under construction in Bensenville, Illinois, will also include facilities for pipe research and developing pipe products.

American Steel Foundries Subsidiary

Griffin also operates foundries in St. Paul; Denver; Salt Lake City; Tacoma; Kansas City and Muncie, Kansas; Chicago; Cincinnati; Colton, California; and two in Canada. Griffin is a subsidiary of American Steel Foundries, which has 27 plants in 15 states and Canada.

Service Lines

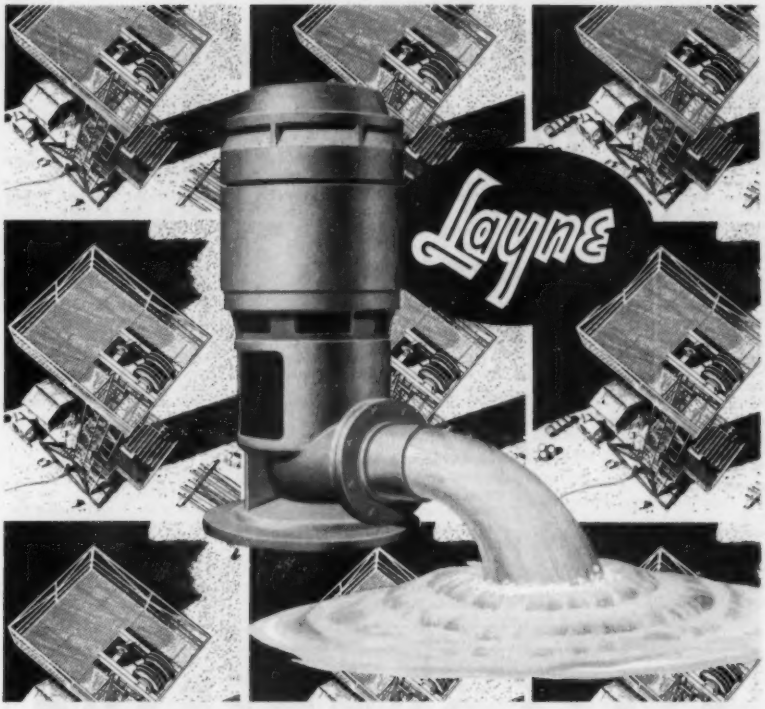
Vertical turbine pumps, redesigned to offer high efficiencies over wider operating ranges, are described, with photographs, cutaway drawings, and charts, in a new 16-page booklet. A copy of "New UHF Vertical Turbine Pumps" may be obtained by writing Worthington Corp., Harrison, N.J.

Pneumatic transmitters, for measurement of flow rates, loss of head, and liquid levels, are the subject of an illustrated, 4-page bulletin. For detailed information about these devices, Bulletin Ref. No. 285.20A-1 is available from B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R.I.

Grouting is discussed in detail in a new 16-page publication. Complete with illustrations and charts, the bulletin describes proper methods and recommended mixes. Bulletin E1d is available from The Master Builders Co., Cleveland 3, Ohio.

Concise information about all the products and equipment manufactured by Allis-Chalmers Mfg. Co. is available in a 32-page, full-color booklet. A copy of "Better Tomorrows Begin Today at Allis-Chalmers" may be obtained by writing the company at Box 512, Milwaukee 1, Wis.

Rubber gasket joints for steel pipe are described and illustrated in a new 8-page pamphlet, "The Inside Story of Steel Pipe Rubber Gasket Joints." Included in the booklet are cross-section drawings, specifications, and details of installation. Copies are available from Kaiser Steel Corp., Fabricating Div., Box 95, Fontana, Calif.



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Layne Pump Design, manufacture and installation are only part of the complete water service offered by the Layne organization. Other services include: Initial surveys, explorations, recommendations, site selection, foundation and soil sampling, well drilling, well casings and screens, gravel wall wells, construction of water systems, complete research staff and facilities, maintenance and service, chemical treatment of water wells, water treatment. *Write for Bulletin No. 100.*

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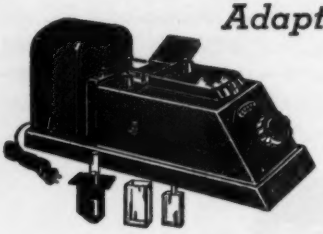

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These are only a few of the many advanced features of the new Mueller B-100 Drilling, Tapping and Inserting Machine. They are typical, however, of the attention to detail in research, design and engineering that become a part of every Mueller product used by the water industry.

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Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Filtration Plant, Pumping Station, Transmission Line:
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Simplex Valve & Meter Co.
Sparling Meter Co.

Meters, Industrial, Commercial:
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B-I-F Industries, Inc.—Builders
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Burgess-Manning Co., Penn Instruments Div.
Calmet Meter Div., Worthington Corp.
Gamon Meter Div., Worthington Corp.
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Neptune Meter Co.
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Mixing Equipment:
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F. B. Leopold Co.

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Worthington Corp.

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Wilbur & Williams Co., Inc.

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American Cast Iron Pipe Co.
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United States Pipe & Foundry Co.
R. D. Wood Co.

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Cast Iron Pipe Research Assn.
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Pipe Locators; see Locators, Pipe

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Carus Chemical Co.

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Peerless Pump Div.
C. H. Wheeler Mfg. Co.

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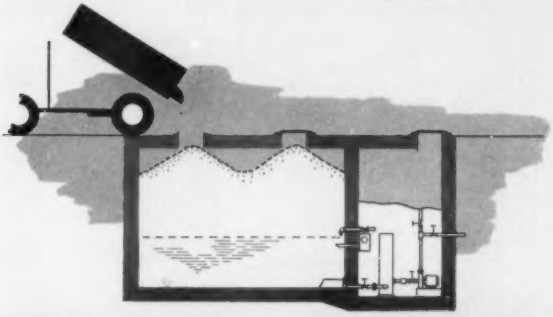
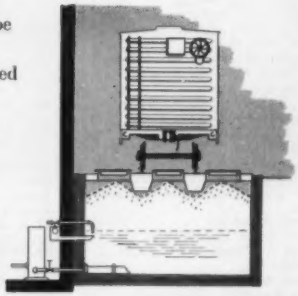


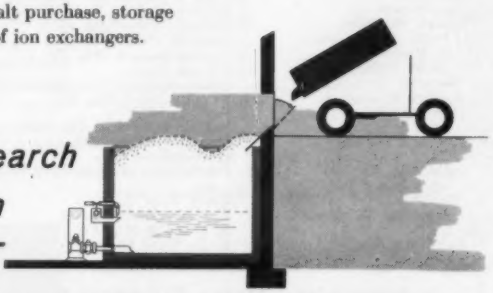
SALT DELIVERY

How it can affect design of water softening installations

Every method of salt delivery—by rail, truck or barge, in bags or bulk—presents it own special problems of plant design. For example: What plant area should be designated for receiving salt? What's the best salt-unloading method to specify? Where will salt be stored and dissolved to make brine? The job of answering these questions has been complicated in recent years by the greatly increased salt tonnages required in today's large-capacity water-softening installations.



If you foresee a plant-design problem involving salt delivery, contact International Salt Company. With over 50 years of experience and continuing research in all phases of salt handling and brine production, International is fully prepared to give you expert, comprehensive information and technical assistance on any matter in connection with salt purchase, storage and dissolving for regeneration of ion exchangers. This service is free of charge.



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Ludlow Valve Mfg. Co., Inc.
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Henry Pratt Co.
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Mueller Co.
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Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.
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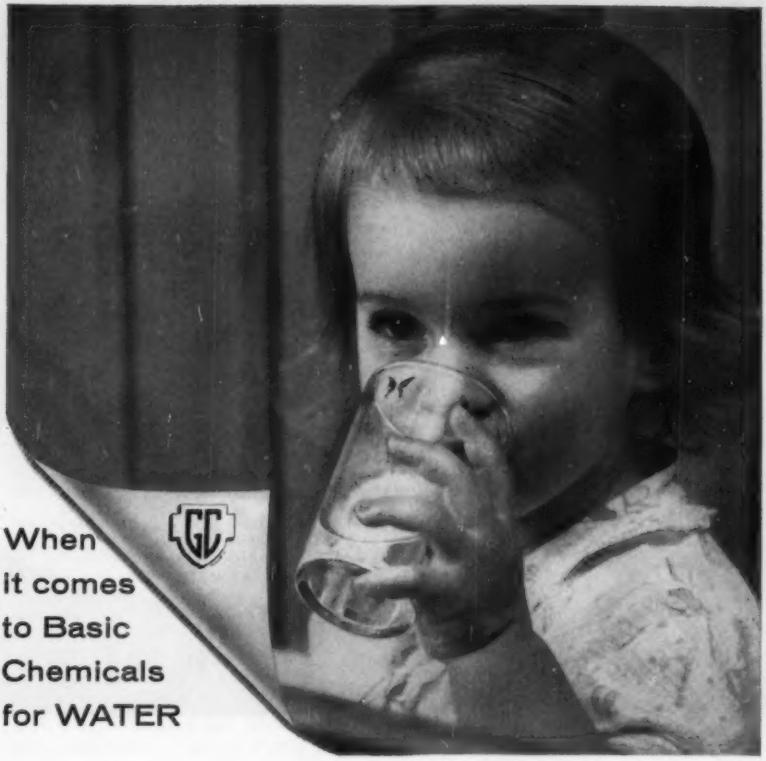
Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1957 AWWA Directory.



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The modern Canoe Brook Station of the Commonwealth Water Company is currently fulfilling the water requirements of several New Jersey suburban communities. A Dorrco PeriFilter System was selected for this plant as the most economical solution for local conditions. Heart of the system are four Dorrco Hydro-Treators, each 63'6" in diameter with a 16'3" sidewater depth, and each surrounded by an annular sand filter. Flow through each unit is normally 2.5 MGD, with a maximum unit flow of 3.75 MGD enabling a total plant flow of 15 MGD. The Canoe Brook plant was designed to remove turbidity, color, iron and manganese.

The Summit, New Jersey installation is another endorsement of the widely proven advantages of the Dorrco PeriFilter System and Dorrco Hydro-Treators for removal of turbidity, color, hardness, or algae from municipal water supplies. For more information write for Bulletins 9041 and 9042.

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